F9

EMD

# OPERATING MANUAL

## F9 LOCOMOTIVES

GENERAL MOTORS LOCOMOTIVES

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GENERAL MOTORS LOCOMOTIVES

# DIESEL LOCOMOTIVE
# OPERATING MANUAL
# NO. 2315

*for*

## MODEL F9

***With Vapor Car Steam Generator***

FEBRUARY, 1954

**ELECTRO-MOTIVE DIVISION**
GENERAL MOTORS CORPORATION
LA GRANGE, ILLINOIS, U.S.A.

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## INTRODUCTION

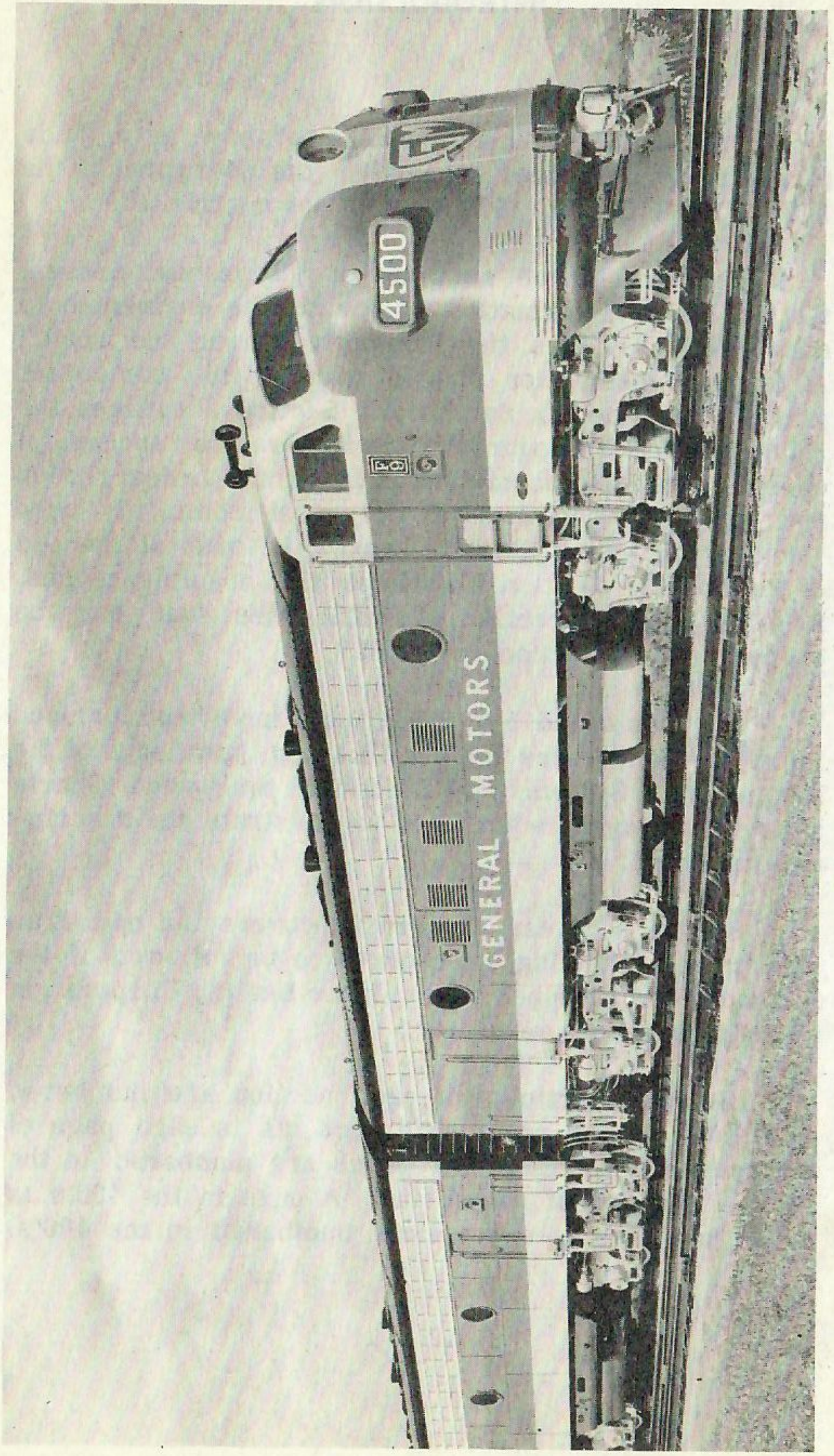
The purpose of this manual is to serve as a guide for railroad personnel engaged in the operation of the ELECTRO-MOTIVE 1750 HP F9 locomotive.

The first three sections of the manual present the necessary information to enable the engineman to successfully operate the locomotive "over the road." A general description and location of the component parts is contained in Section 1. Section 2 outlines the recommended procedures to be followed for successful operation of the locomotive equipment. A description and general operation of the most commonly used "extras," including dynamic brakes, is found at the end of Section 2. Section 3 outlines the possible causes, location, and correction of difficulties that may be encountered while "on the road."

Sections 4 and 5 of the manual have been included for those who desire a more thorough knowledge of the locomotive's Systems and Electrical equipment. Charts and wiring diagrams are used to illustrate the descriptive material.

Section 6, Steam Generator, covers the operation and trouble shooting procedures to be followed if the locomotive is equipped with a Vapor Heating Corporation OK series steam generator.

Principal articles of each section are numbered consecutively for ready reference, as is each page of the section. Articles and pages are numbered in the 100 series type of numbering. A page in the 400's is in Section 4 as is any article numbered in the 400's.



## GENERAL DATA

### F9 AND FP9 DIESEL LOCOMOTIVES

| | |
|---|---|
| Weight (fully loaded) F9A Unit (approx.) | 230,000 lbs. |
| FP9A Unit (approx.) | 258,000 lbs. |
| F9B Unit (approx.) | 230,000 lbs. |
| Fuel Capacity (per unit) | 1,200 gal. |
| Lubricating Oil Capacity (per engine) | 200 gal. |
| Cooling Water Capacity "A" Unit-"G" Valve | 230 gal. |
| "B" Unit-"G" Valve | 215 gal. |
| Steam Generator Water Capacity (if used): | |
| Vertical Tank - FP9A Unit | 820 gal. |
| F9B Unit | 1,200 gal. |
| Hatch Tank - FP9A Unit | 330 gal. |
| (Without dynamic brakes, all units may have an additional 600 gal. hatch tank) | |
| Tank Under 2750 lb. Steam Generator | 200 gal. |

Gear Ratios and Maximum Speeds:

| | | | |
|---|---|---|---|
| 65/12 | 55 MPH | 59/18 | 83 MPH |
| 62/15 | 65 MPH | 58/19 | 89 MPH |
| 61/16 | 71 MPH | 57/20 | 95 MPH |
| 60/17 | 77 MPH | 56/21 | 105 MPH |

| | |
|---|---|
| Sand Capacity (per unit) | 16 cubic feet |
| Number of Drivers (per unit) | 4 pair |
| Wheel Diameter | 40" |
| Weight on Drivers | 100% |
| Truck Centers (F9) | 30' 0" |
| Truck Centers (FP9) | 34' 0" |
| Truck - Rigid Wheel Base | 9' 0" |
| Minimum Curve Radius | 250' |
| Center of Gravity Above Rail (approx.) | 63" |
| Overall Length Over Coupler F9A Unit | 50' 8" |
| FP9A Unit | 54' 8" |
| F9B Unit | 50' 0" |
| Maximum Height Above Rail | 15' 0" |
| Maximum Width Over Handholds | 10' 8" |

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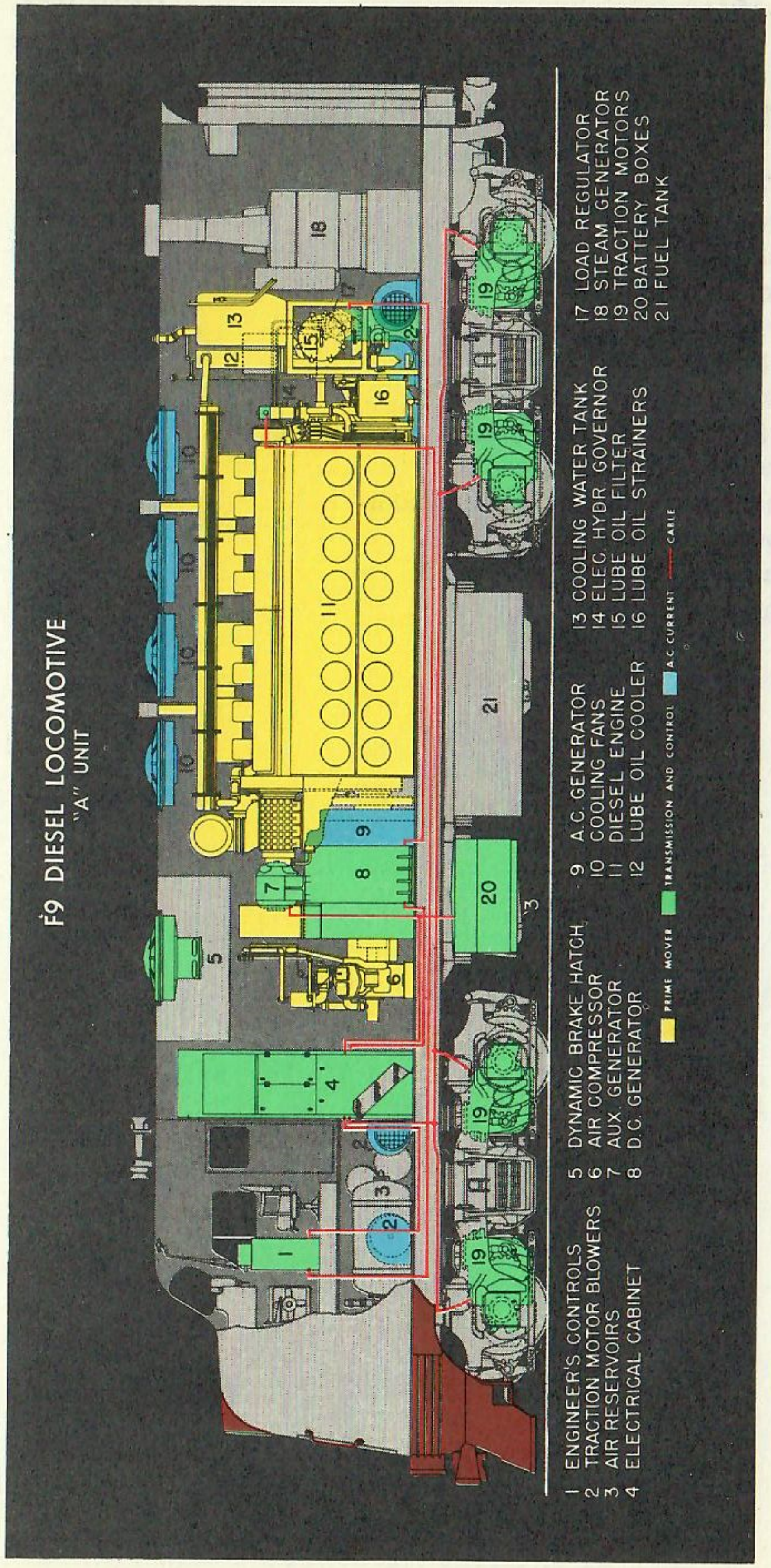
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"A" UNIT
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3 AIR RESERVOIRS
4 ELECTRICAL CABINET
5 DYNAMIC BRAKE HATCH
6 AIR COMPRESSOR
7 AUX. GENERATOR
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18 STEAM GENERATOR
19 TRACTION MOTORS
20 BATTERY BOXES
21 FUEL TANK
PRIME MOVER
TRANSMISSION AND CONTROL
A.C. CURRENT
CABLE

General Arrangement
Fig. 1-1

# SECTION 1

## GENERAL DESCRIPTION

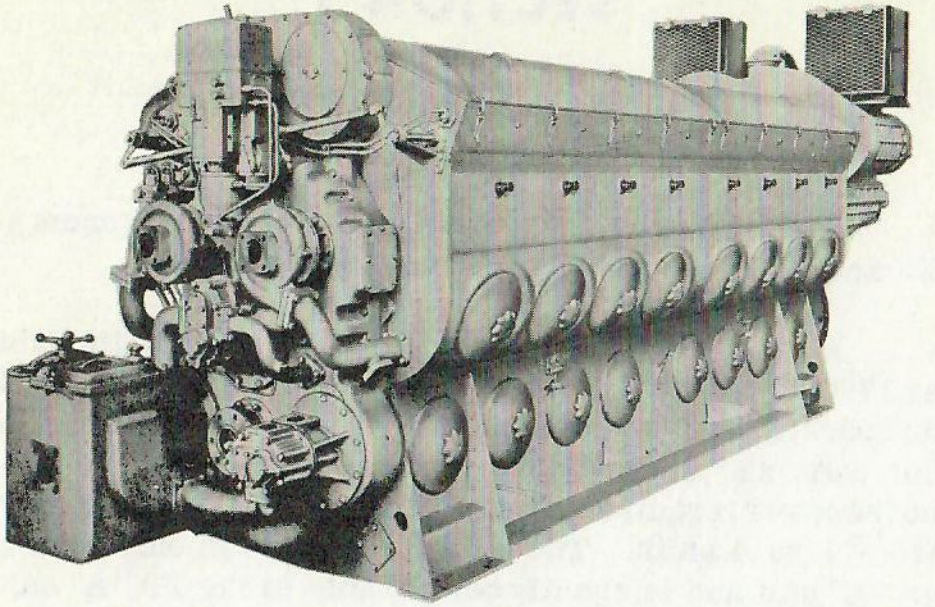
A description and general location of equipment on F9 and FP9 locomotives is given in this section.

A locomotive consists of one or more units rated at 1750 horsepower per unit. Those units equipped with an operating cab are designated "A" units, and those without cabs as "B" or Booster units. Depending upon the horsepower requirements a locomotive will consist of from 1 to 4 units. The FP9 locomotive is only built as an "A" unit and is exactly comparable to the F9 "A" units except that it is 4 feet longer to provide additional steam generator water capacity.

100 **Diesel Engine** The main generator and auxiliaries of these units are driven by a 16-cylinder V-type, 2 cycle, 1750 HP Model 567C Diesel engine, Fig. 1-2. The cylinders have an 8-1/2" bore and a 10" stroke. The two banks of the engine are arranged with respect to each other at an angle of 45°. The engine has a fully scavenging air system and has two blowers for this purpose. The blowers are mounted on the rear end of the engine; each blower is equipped with a separate air filter.

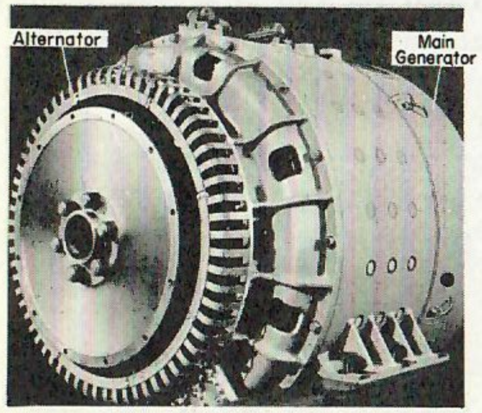
The engine is started by temporarily using the direct coupled main generator as a starting motor. Current from a storage battery "motors" the main generator to rotate the engine.

**NOTE:** In this manual, the word "engine" refers specifically to the Diesel engine; the word "locomotive" refers to a consist of one or more units.



Front Three-Quarter View
Fig. 1-2

101 **Main Generator** The main generator and alternator assembly, Fig. 1-3, is directly connected to the Diesel engine crankshaft through a serrated coupling. The main generator is a constant KW generator which produces direct current at a nominal 600 volts for operation of the traction motors. The armature of the main generator acts as the engine flywheel.

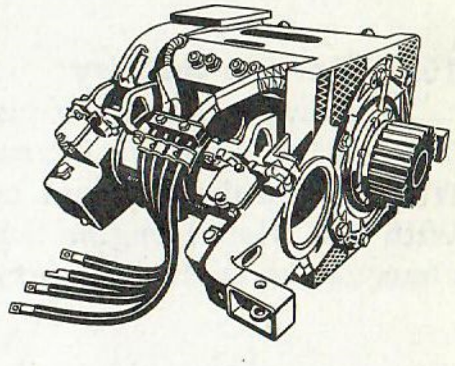


Main Generator
and Alternator
Fig. 1-3

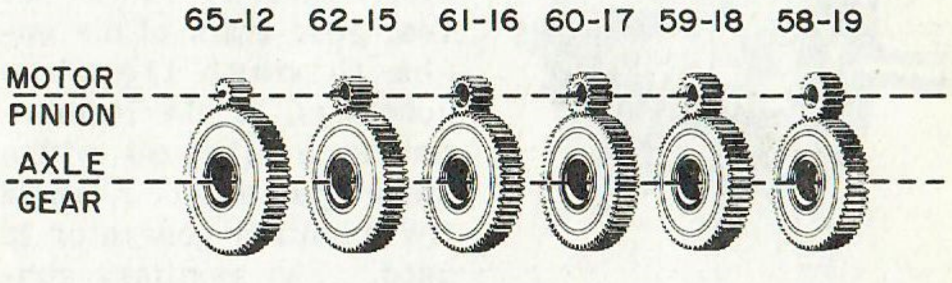
102 **Alternator** The alternator, Fig. 1-3, built into the engine end of the main generator frame, is a three phase alternating current generator. The alternating current (AC) produced is used to drive

the four engine water cooling fans and four traction motor blowers.

103 **Traction Motors** Four Model D37 traction motors, Fig. 1-4, are used in each unit, mounted one on each axle. Each motor is geared to the axle, which it drives, by a motor pinion gear meshing with an axle gear. The gear ratio between the two gears, Fig. 1-5, is expressed as a double number such as 62/15. In this case the axle gear has 62 teeth while the pinion has 15 teeth.



Traction Motor
Fig. 1-4



Gear Ratio Chart
Fig. 1-5

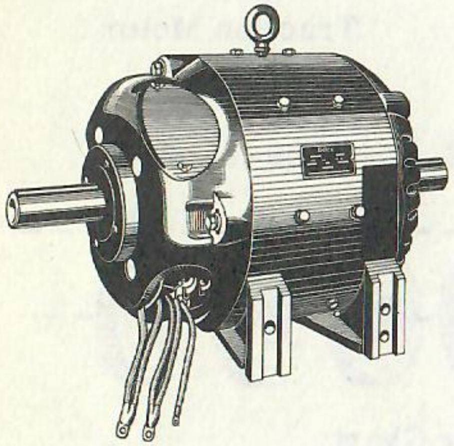
During acceleration, the traction motor electrical hookup is changed to utilize the full power developed by the main generator, within the range of its current and voltage limits. The changes in the traction motor electrical connections is called transition. Four steps of transition are used on the F9 as follows:

1. Series-Parallel
2. Series-Parallel Shunt
3. Parallel
4. Parallel-Shunt

The changing of the traction motor electrical connections or transition is completely automatic during locomotive acceleration or deceleration on F9 locomotives. There is no provision for effecting manual transition on a F9 locomotive or for forestalling the automatic transition.

## AUXILIARY EQUIPMENT

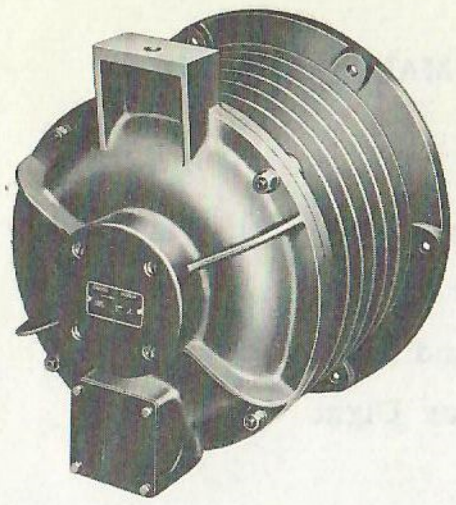
104 **Storage Battery** Power from a 32 cell, 64-volt storage battery is used to start the Diesel engine. The storage battery boxes are located adjacent to the front end of the fuel tank on each side of the locomotive. With the Diesel engine running, the auxiliary generator charges the storage battery.



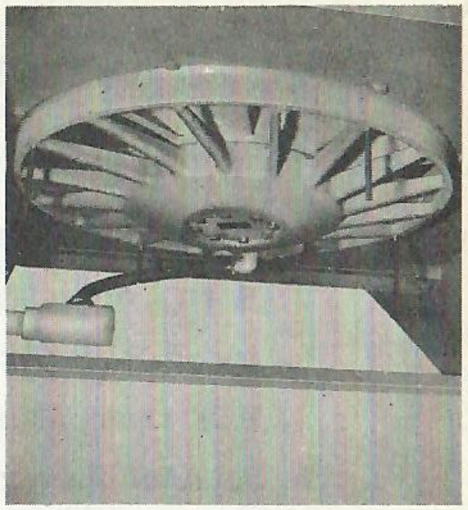
Auxiliary Generator
Fig. 1-6

105 **Auxiliary Generator** A 10 KW auxiliary generator, Fig. 1-6, is driven directly from the rear gear train of the engine through flexible couplings. If the locomotive is equipped with a steam generator, an 18 KW auxiliary generator is used. The auxiliary generator produces direct current at 74 volts to charge the storage battery and supply the low voltage circuits for lighting, main generator battery field excitation and fuel pump operation.

106 **Traction Motor Blowers** The F9 is equipped with four alternating current driven traction motor blower motors, Fig. 1-7. Each motor has a fan, or blower wheel, mounted on its rotor shaft and supplies cooling air to one traction motor. The speed of the blower motor varies in proportion to the speed of the Diesel engine.



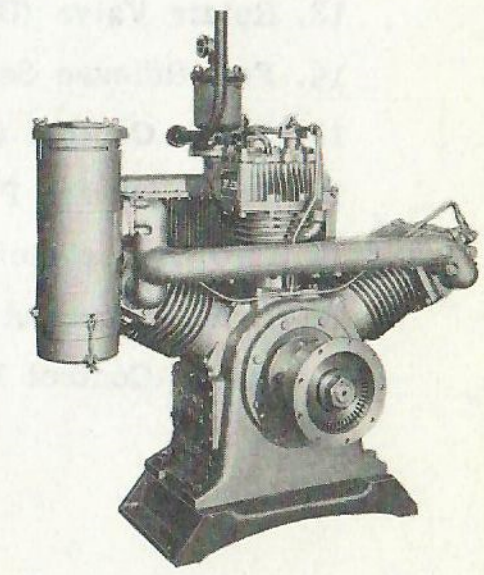
Traction Motor Blower
Fig. 1-7



Radiator Cooling Fan
Fig. 1-8

107 **Radiator Cooling Fans** Four alternating current driven cooling fan motors, Fig. 1-8, are mounted in the roof of the locomotive above the cooling water radiator sections. A fan mounted on each rotor shaft draws air through the radiator, removing heat from the engine cooling water. The speed of the cooling fan motor varies in proportion to the speed of the Diesel engine.

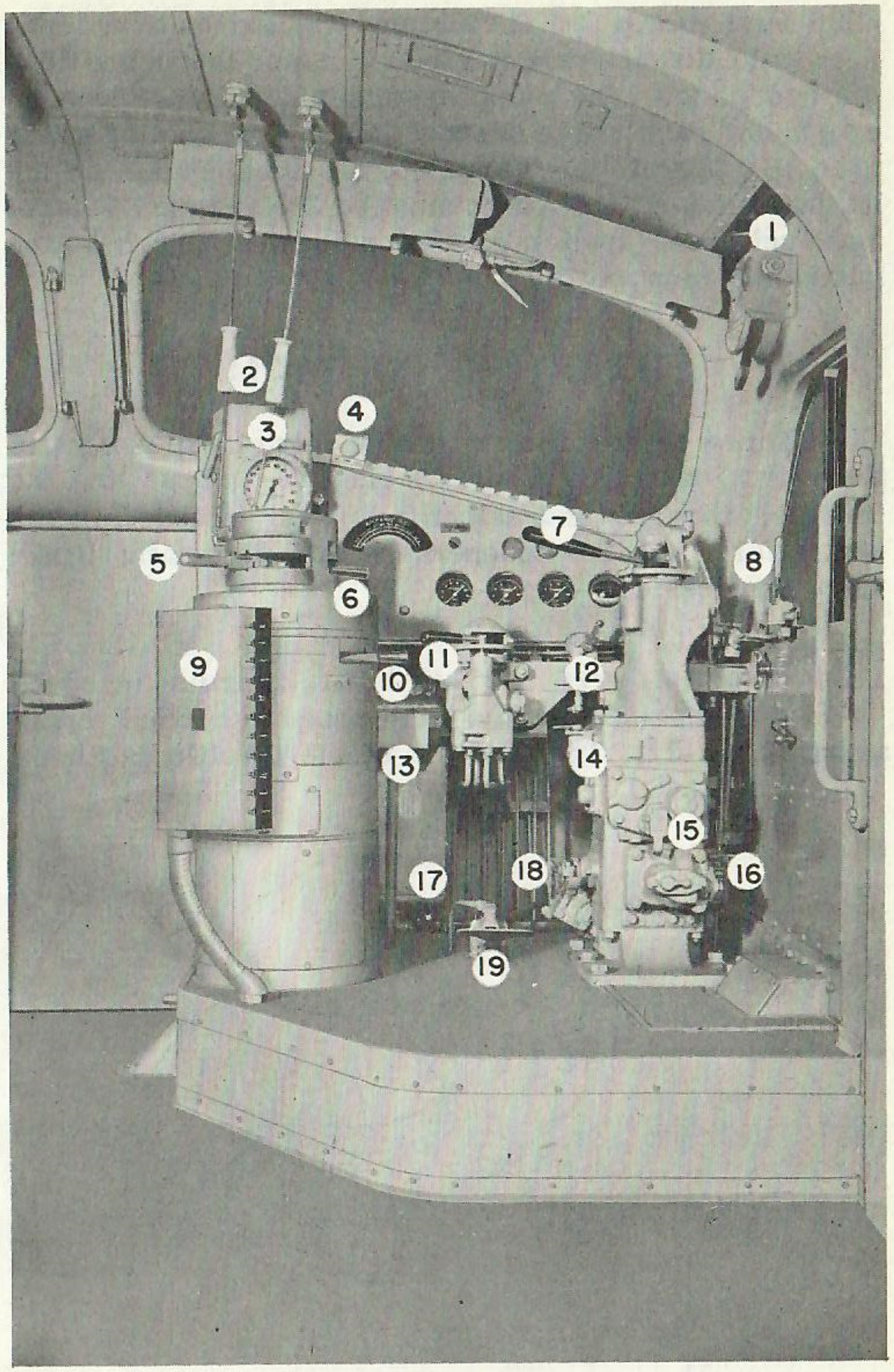
108 **Air Compressor** A 3-cylinder, two stage air cooled air compressor, Fig. 1-9, is driven through a flexible coupling from the armature shaft of the main generator. Basically, the F9 is equipped with a Model WXO air compressor which has a rating of 234 CFM displacement at 835 RPM.



Air Compressor
Fig. 1-9

## LEGEND OF ENGINEMAN'S CONTROLS

1. Signal Light Control Switch (If Used)
2. Horn Cords (Rear & Front)
3. Speed Recorder and Indicator
4. PCS-Open Indicator Light
5. Selector Lever
6. Throttle Lever
7. Automatic Brake Valve Handle
8. Sanding Valve
9. Control Push-Button Switch Box
10. Reverse Lever
11. Independent Brake Valve Handle
12. Signal Bell Air-Valve
13. Rotair Valve (Behind Guard)
14. Full Release Selector Cock
15. Safety Control Cock
16. First Service Position Cock
17. Cab Heater Steam Valve
18. Brake Pipe Cut-Out Cock
19. Safety Control Foot Pedal



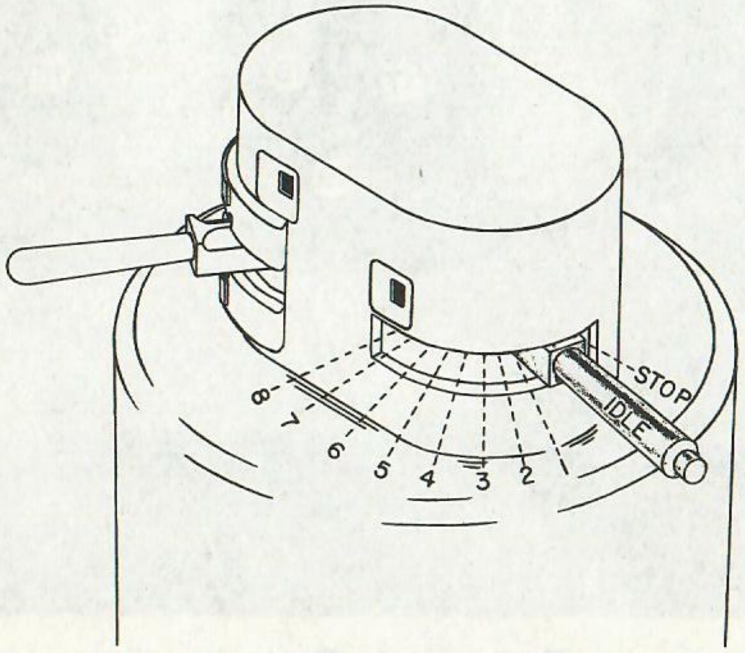
Engineman's Control
Fig. 1-10

109 **Fuel Pump** The fuel pump is driven by a separate direct current electric motor through a flexible coupling. The pump assembly is mounted on the equipment rack which supports the engine cooling water tank. To operate the fuel pump, the "Fuel Pump" switch on the engine control panel must be ON and the "Control and Fuel Pump" switch on the enginemen's push-button switch box must be IN.

## OPERATING CONTROLS

Three levers and two brake valve handles control the entire operation of the locomotive. These are the throttle, reverse and selector levers, mounted in the controller, and the independent and automatic brake valve handles. See Fig. 1-10.

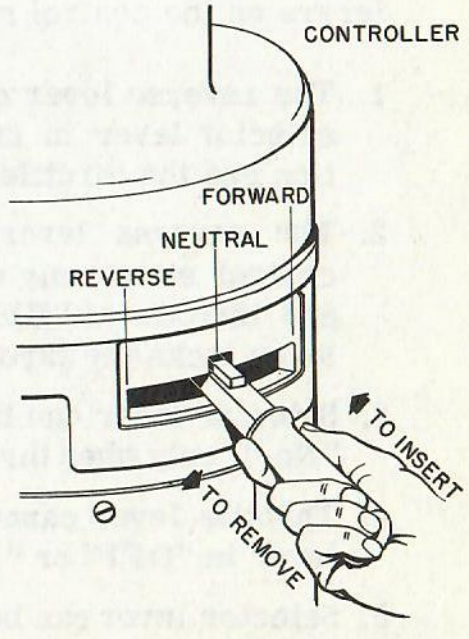
110 **Throttle Lever** This lever controls the speed of the engines and the train speed in normal operation, Fig. 1-11. The position of the throttle is shown in the illuminated indicator above the lever. The throttle has ten positions, Stop, Idle and running speeds 1 to 8. Stop can be obtained by depressing the emergency stop button on the end of the throttle lever and pushing the throttle lever one step beyond the idle position; this stops all engines. Idle position is as far forward as the throttle lever can be moved without depressing the emergency stop button. Each running notch on the throttle increases the engine speed 80 RPM from 275 RPM at idle to 835 RPM at full throttle. The throttle may be opened as rapidly as desired PROVIDING OPERATING CONDITIONS AND TRAIN CONSIST PERMITS. Normally, the throttle should be opened one notch at a time. The throttle may be closed completely with one motion in an emergency, but should be closed only one notch at a time in normal operation.



Throttle Lever Position
Fig. 1-11

111 **Reverse Lever** The reverse lever, Fig. 1-12, has three positions: FORWARD, NEUTRAL and REVERSE. Direction in which the locomotive moves is controlled by movement of this lever to the forward or reverse position. With the reverse lever in neutral, no power will be developed if the throttle is opened, even though the engine speed will increase. The reverse lever should be moved ONLY when the locomotive is standing still.

The reverse lever can be removed from the control stand only when the lever is in the "Neutral" position, the throttle is in "Idle" and the selector lever is in "Off". Removal of the reverse lever locks the



Reverse Lever Positions
Fig. 1-12

operating controls in the controller. Remove the reverse lever from all non-operating control stands.

112 **Selector Lever** F9 and FP9 locomotives are basically equipped with 3-relay automatic transition. On such locomotives transition is FULLY AUTOMATIC, both forward and backward, and no provision is made for making transition manually on such units. However, a selector lever is supplied with "A" units solely for the purpose of controlling dynamic braking and/or effecting manual transition on older type units not equipped with automatic transition.

On locomotives equipped with dynamic brakes, moving the selector lever to the "Off" position does not establish any portion of the braking circuit. Moving the lever to the "B" position partially establishes the braking circuit. Moving the lever farther, to the right of "B", completes the circuit and increases the braking effort (See Art. 229 for dynamic brake operation).

113 **Mechanical Interlocks on the Controller** The levers on the control stand are interlocked so that:

1. The reverse lever can be operated only with the selector lever in either "No. 1" or "OFF" position and the throttle at "IDLE."
2. The reverse lever can be removed from the control stand only with selector lever in "OFF" and throttle at "IDLE." Removing the reverse lever locks the throttle and selector levers.
3. Selector lever can be moved between "OFF" and "No. 1" only when throttle is in "IDLE" or "STOP."
4. Throttle lever cannot be advanced with selector lever in "OFF" or "B" position.
5. Selector lever can be moved to "B" position only with the throttle in "IDLE" and the reverse lever in Forward or Reverse.

6. Throttle can be moved to "STOP" with reverse and selector levers in any position.
7. Throttle lever in "STOP" locks against movement of the reverse lever, but the selector lever may be moved to any position if reverse lever is in Forward or Reverse.

NOTE: When using the selector lever to effect manual transition from 2 to 3 and 3 to 2 on older type units, the throttle should be reduced to Run 6 before moving the selector lever to the desired position.

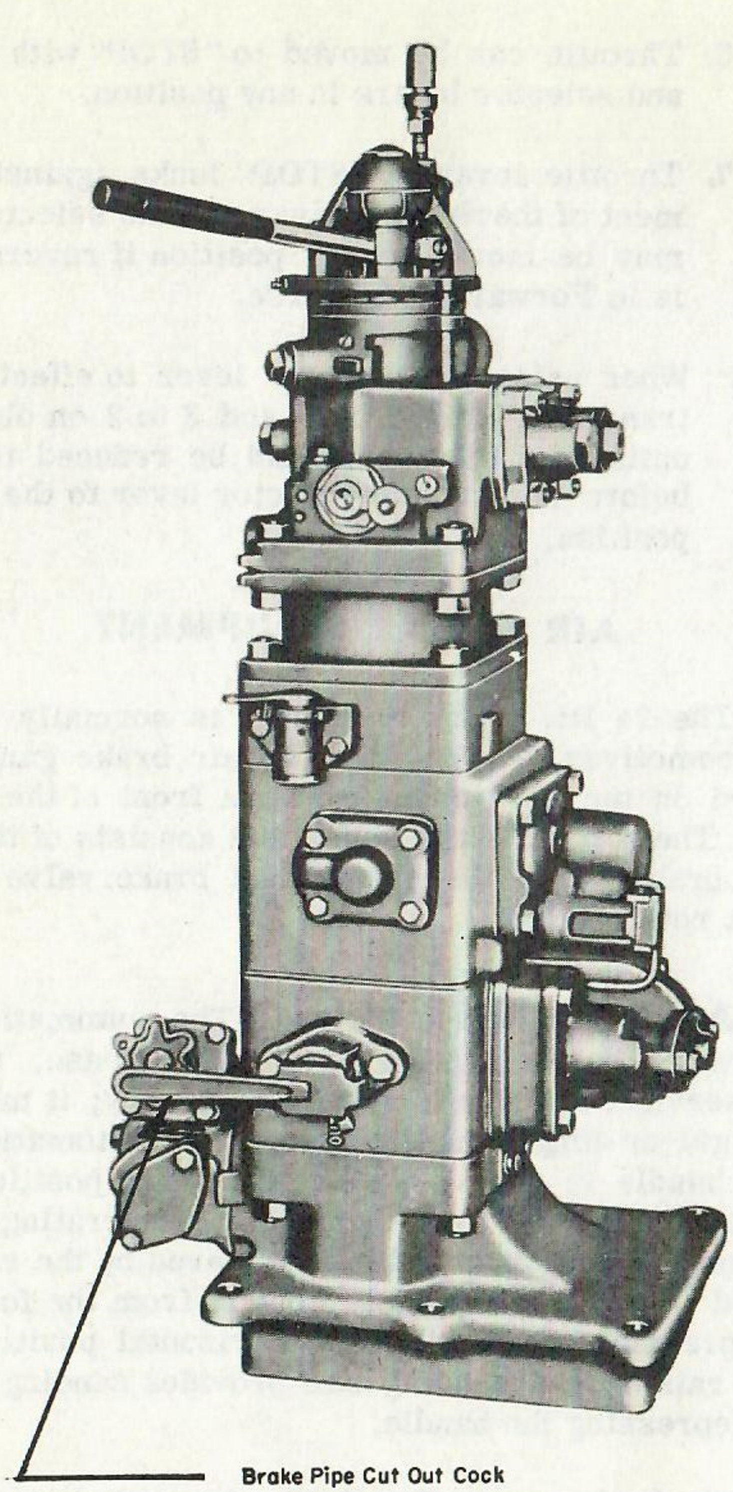
## AIR BRAKE EQUIPMENT

The 24 RL brake equipment is normally used on F9 locomotives, Fig. 1-13. The air brake gauges are located on the instrument panel in front of the engineman. The cab air brake equipment consists of the automatic brake valve, the independent brake valve and the K-2-A rotair valve.

114 **Automatic Brake Valve** The automatic brake valve handle has 6 positions -- release, running, first service, lap, service and emergency; it may be of the rigid or hinged handle type. The automatic brake valve handle is removable in the running position. The handle should be removed from all non-operating control stations. The hinged handle, if required by the railroad, is used to suppress a safety control from the foot pedal by depressing the handle to a horizontal position. On some railroads a sanding bail provides sanding by further depressing the handle.

The brake valve, Fig. 1-13, also contains:

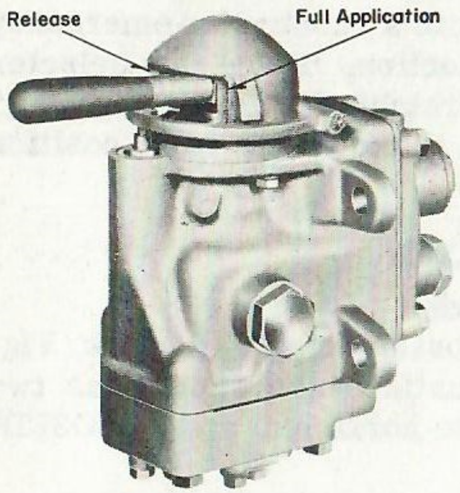
1. Brake valve cutout cock, located on the filling piece portion.



24RL Brake
Fig. 1-13

2. Safety control cutout cock, located on the service application portion.
3. First service position cock.
4. Full release selector cock.

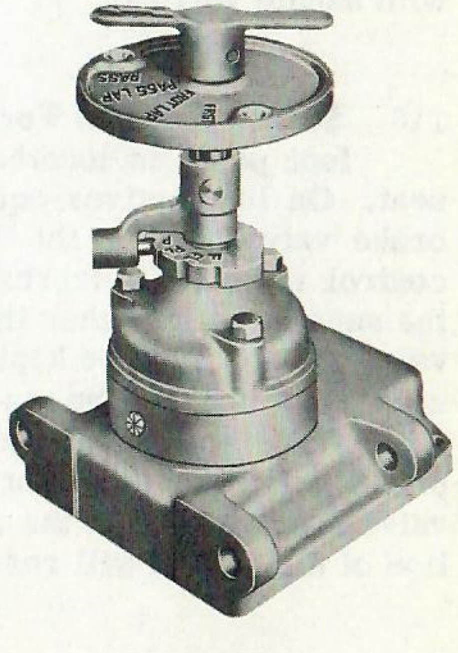
115 **Independent Brake Valve** The S-40-F independent brake valve handle has two positions, release and full application, with the application zone between the two positions. The brake valve, Fig. 1-14, is of the self-lapping type which automatically laps off the flow of air and maintains brake cylinder pressure, when the application pressure reaches the value corresponding to the position of the brake valve handle in the application zone. Release of locomotive brakes after automatic application is obtained by depressing the independent brake valve handle in release position.



Independent Brake Valve
Fig. 1-14

116 **Rotair Valve** The K2A valve used in "A" units, has four positions: "Freight", "Freight Lap", "Passenger", "Passenger Lap", Fig. 1-15.

The rotair valve is used to "cut in" the features



Rotair Valve
Fig. 1-15

which control the rate of locomotive brake cylinder pressure buildup during an emergency or penalty application of the air brake, and to cut out the independent brake valve in the trailing "A" unit. With long freight trains, the handle is placed in "FRGT" position in the lead unit and in "FRGT Lap" position in all trailing "A" units. With passenger trains, short freight trains, and when handling light locomotives, the handle is placed in the "PASS" position in the lead units and in the "PASS Lap" position in all trailing "A" units.

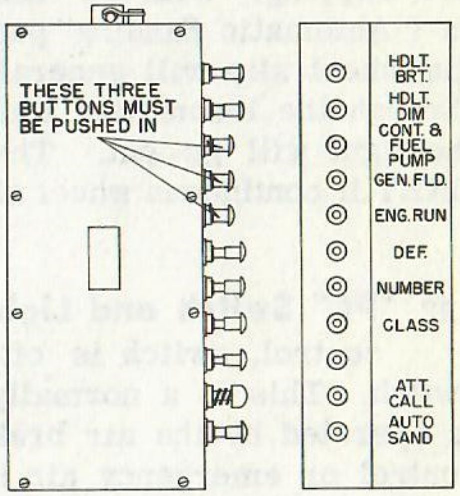
"B" units are equipped with a "controlled emergency cock" on the control valve section. Place this selector cock on all "B" units in the "Freight" ("F") or "Passenger" ("P") position to correspond to the rotair valve position in the lead "A" unit.

117 **Brake Pipe Cut-out Cock (Double-heading Cock)** With 24RL brakes, the brake pipe cutout cock, Fig. 1-13, mounted on the automatic brake stand, has two positions, "OPEN" with handle horizontal and "CLOSED" with handle vertical.

118 **Safety Control Foot Pedal** The safety control foot pedal is located in front of the engineman's seat. On locomotives equipped with a hinged automatic brake valve handle, the handle provides an alternate control when it is depressed sufficiently to just contact the sanding bail. Either the pedal or the automatic brake valve handle must be kept depressed at all times except when the locomotive is stopped and the locomotive brakes are applied (30 pounds or more brake cylinder pressure). If both the foot pedal and the automatic brake valve are released at the same time, a penalty application of the brakes will result.

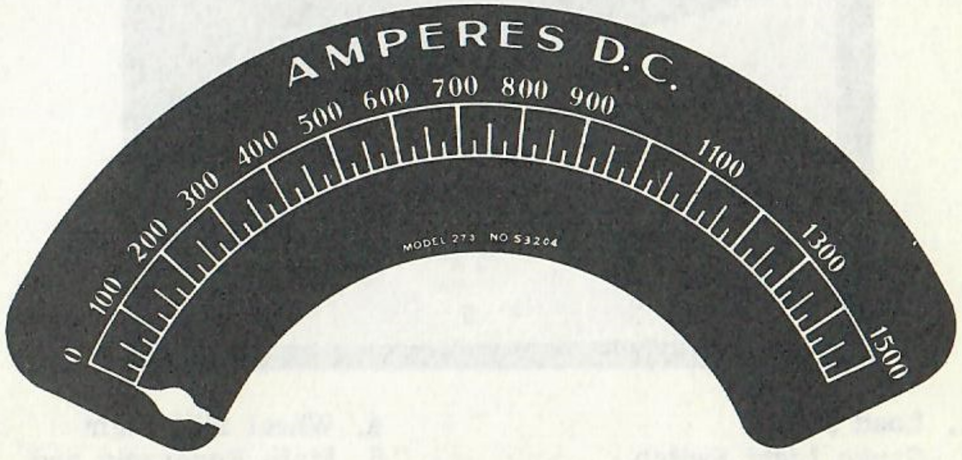
## ENGINEMAN'S INSTRUMENT PANEL

119 **Push-button Switch Box** The engineman's push-button switch box, Fig. 1-16, contains switches for control, lights and accessory circuits. Name plates identifying each switch are illuminated by lights inside the switch box. The "Gauge Light" switch operates these lights. During normal locomotive operation, the "Control and Fuel Pump," "Engine Run" and "Generator Field" switches must be pressed IN, in the operating cab only. These switches must be OUT at all non-operating control stations.



Push-Button Switch Box
Fig. 1-16

120 **Load Indicating Meter** This meter is an accurate guide to the load and pulling force of the locomotive, Fig. 1-17. The meter is connected into the leads of the No. 2 motor. Since the amperage

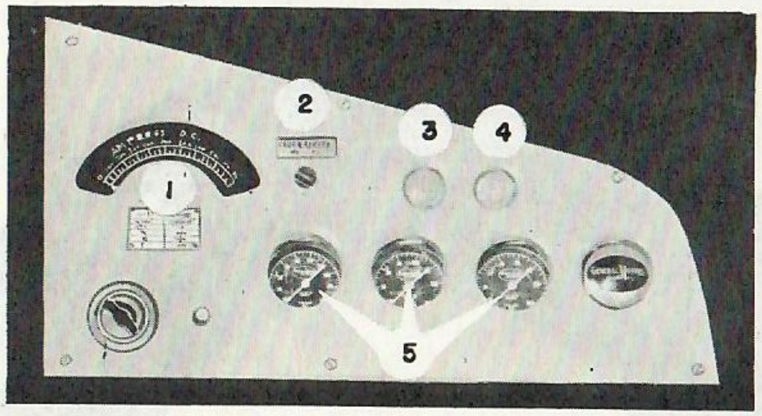


Load Indicating Meter
Fig. 1-17

is the same in all motors; each motor receives the amount of current shown on the meter. The dial of the meter is graduated into amperes from 0 at the left to 1500 amperes at the extreme right of the scale.

121 **Wheel Slip Light** "Flashing" of the wheel slip light located on the engineman's instrument panel, Fig. 1-18, during power operation, indicates the wheels are slipping. With the "Automatic Sanding" feature cut in ("Automatic Sanding" push-button switch pressed IN), the wheel slip will generally be corrected immediately through the locomotive wheel slip control system and the light will go out. The throttle should be reduced ONLY if continuous wheel slip occurs.

122 **"PC" Switch and Light** The PC, or pneumatic control, switch is often called the power cutoff switch. This is a normally closed electric switch that is operated by the air brake system. During a safety control or emergency air brake application this switch opens and automatically reduces the power output of the locomotive. When tripped open the PC switch immediately reduces the speed of all engines to Idle. If the throttle is left in the fifth or sixth notch when the PC switch is tripped, the engines will stop. A white "PC Switch Open" indicating light, mounted on the engineman's instrument panel, will flash on whenever the PC Switch is tripped.



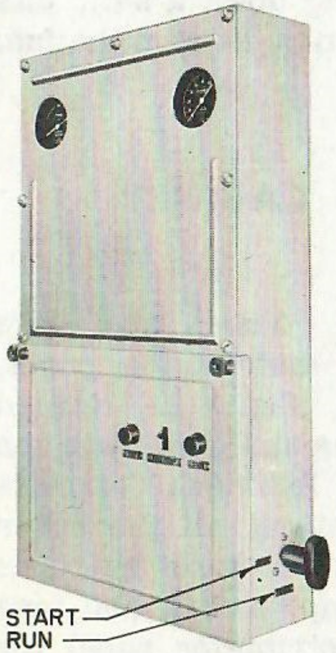
1. Load Meter
2. Gauge Light Switch
3. Brake Warning Light
4. Wheel Slip Light
5. Main Reservoir and Air Brake Gauges

Engineman's Instrument Panel
Fig. 1-18

The PC switch automatically resets itself provided that (1) the throttle is returned to IDLE and (2) control of the brake is recovered (See Section 3 for method of recovering control of the brake).

123 **Air Gauges** These are standard air gauges mounted on the engineman's instrument panel, Fig. 1-18. Each gauge is clearly labeled as to its function.

## ENGINE CONTROL PANEL



Isolation Switch
Fig. 1-19

124 **Isolation Switch** This switch, Fig. 1-19, has two positions, START (handle horizontal) and RUN (handle vertical). In START position, the power plant is "isolated" (off the line) from the control circuit, and the engine speed is reduced to idle. The engine will remain at idle speed and will not respond to throttle control. The power contactors in electrical control cabinet will not operate when control levers are normal. The "Alternator Failure" light and alarm bell is inoperative.

Engine START and STOP buttons are effective only with the switch in the START position.

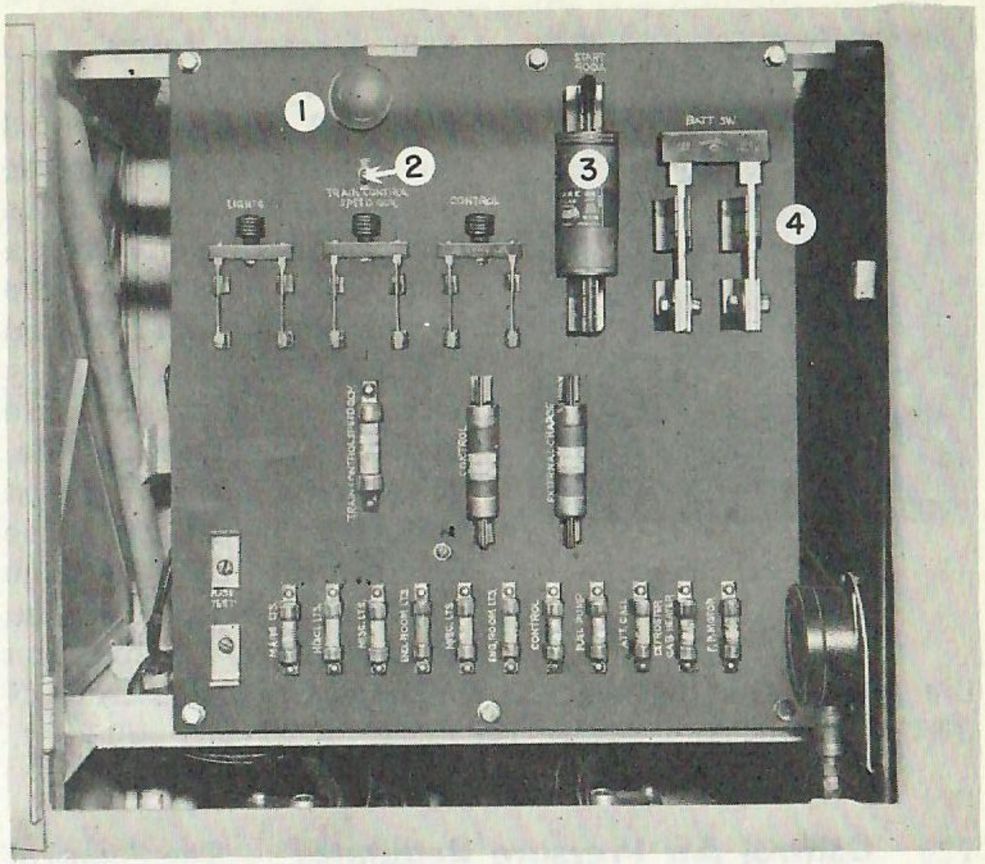
The isolation switch must be in the RUN position for the unit to develop power. The isolation switch should be moved only with the engine at idle speed or stopped. Use the manual layshaft lever to bring the engine to idle or stop when the locomotive is under power or in dynamic braking. If the isolation switch is in the START position, do not place it in RUN while operating in dynamic braking.

125 **Engine Start and Stop Buttons** The engine start and stop buttons, Fig. 1-19, located on the engine control panel are operative only with the isolation switch in the START position. When starting the Diesel engine, press START button in firmly and hold until engine starts (not more than fifteen seconds). To normally stop engine, press STOP button in firmly and hold in until engine STOPS.

126 **Fuel Pump Switch** The fuel pump switch on the engine control panel operates the fuel pump in that one particular unit and must be "ON" when engine is running. When isolating and shutting down a unit, this switch is placed in the "OFF" position to stop the fuel pump, Fig. 1-19.

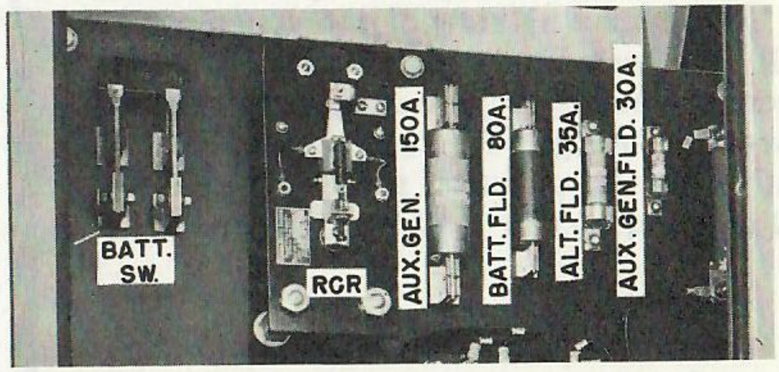
## ELECTRICAL CONTROL CABINET

127 **Fuses and Knife Switches** Fuses and knife switches are mounted on the distribution panel, Fig. 1-20, and the low voltage panel, Fig. 1-21, located in the electrical cabinet. All the fuses and knife switches are clearly labeled to identify the individual circuits they protect. During normal operation, all the fuses should be securely in place and all the knife switches should be closed. A fuse test lamp, switch and fuse test blocks are mounted on the distribution panel for fuse testing.

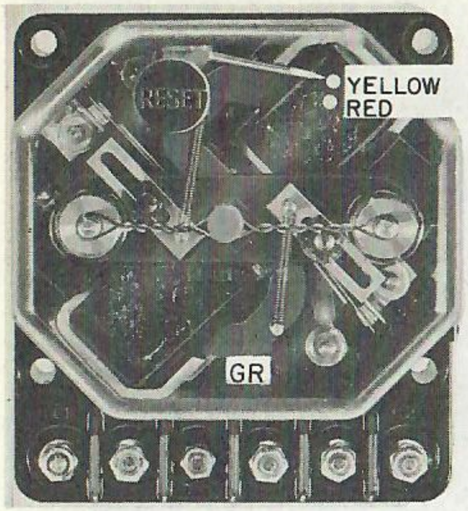


1. Fuse Test Lamp
2. Fuse Test Switch
3. Starting Fuse 400A
4. Battery Switch

Distribution Panel
Fig. 1-20



Low Voltage Panel
Fig. 1-21



Ground Relay
Fig. 1-22

### 128 Ground Relay

The ground relay, Fig. 1-22, is located behind the small glass window on the engineroom side of the electrical cabinet. With a tripped ground relay, the power output of the troubled unit is automatically stopped and the engine speed is reduced to idle. If the ground relay tripped while the throttle was in the 5th or 6th notch, the engine would stop. To reset the ground relay, "push in" on the relay reset button. ALWAYS place the ISOLATION SWITCH in START before resetting the ground relay.

### 129 Control Air Pressure Regulator

The "control air" for operating the power contactors, reverser drum and cam switch is supplied from the main reservoir and reduced to 90 ± 3 pounds by the control air pressure regulator. The regulator, Fig. 1-23, is located behind the steps leading into the operating cab on the right (engineman's) side of the locomotive. A bolt and locknut on top of the regulator provides means of adjustment. The control air pressure gauge, Fig. 1-24, mounted adjacent to the distribution panel in the electrical cabinet, should read 90 ± 3 pounds.

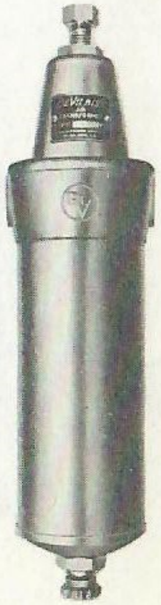
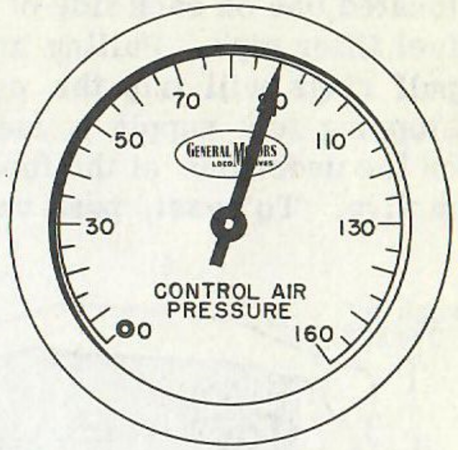


Fig. 1-23

### 130 Alarm Indications

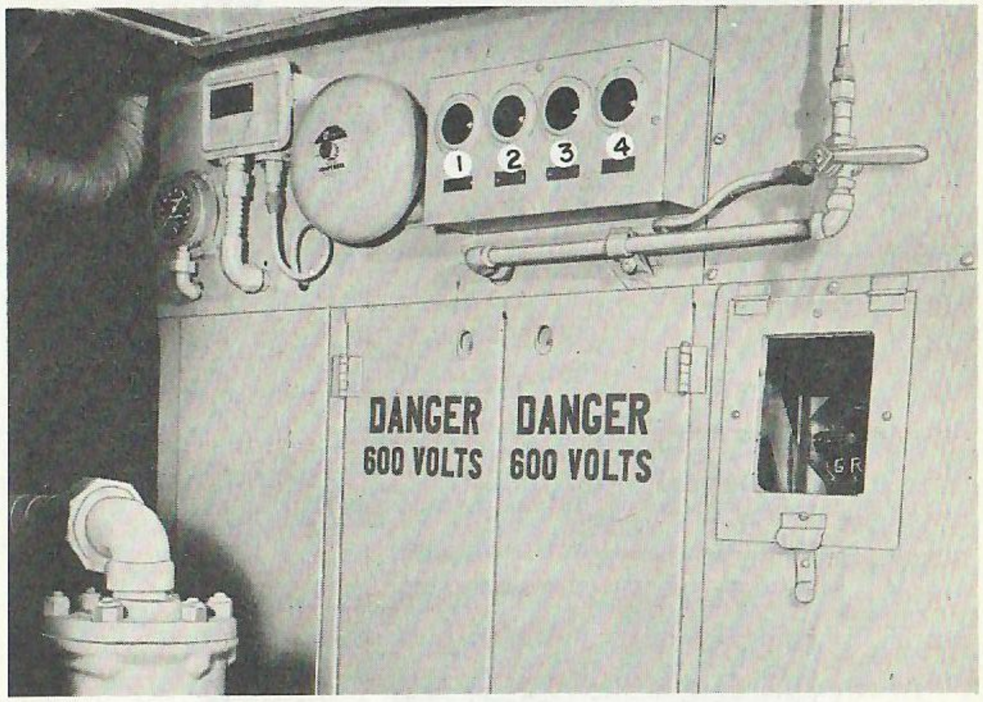
An alarm bell and four signal lights are located on the engineroom side of the electrical cabinet, Fig. 1-25. These lights indicate (1) Hot Engine, (2) Steam Boiler Stopped, (3) Low Oil Pressure, and (4) Alternator Failure (No AC Power). In case of an alarm, the bell will ring in all units, but a signal light will flash on only in the unit affected.



Control Air Gauge
Fig. 1-24

### 131 Emergency Fuel Cut-Off Ring

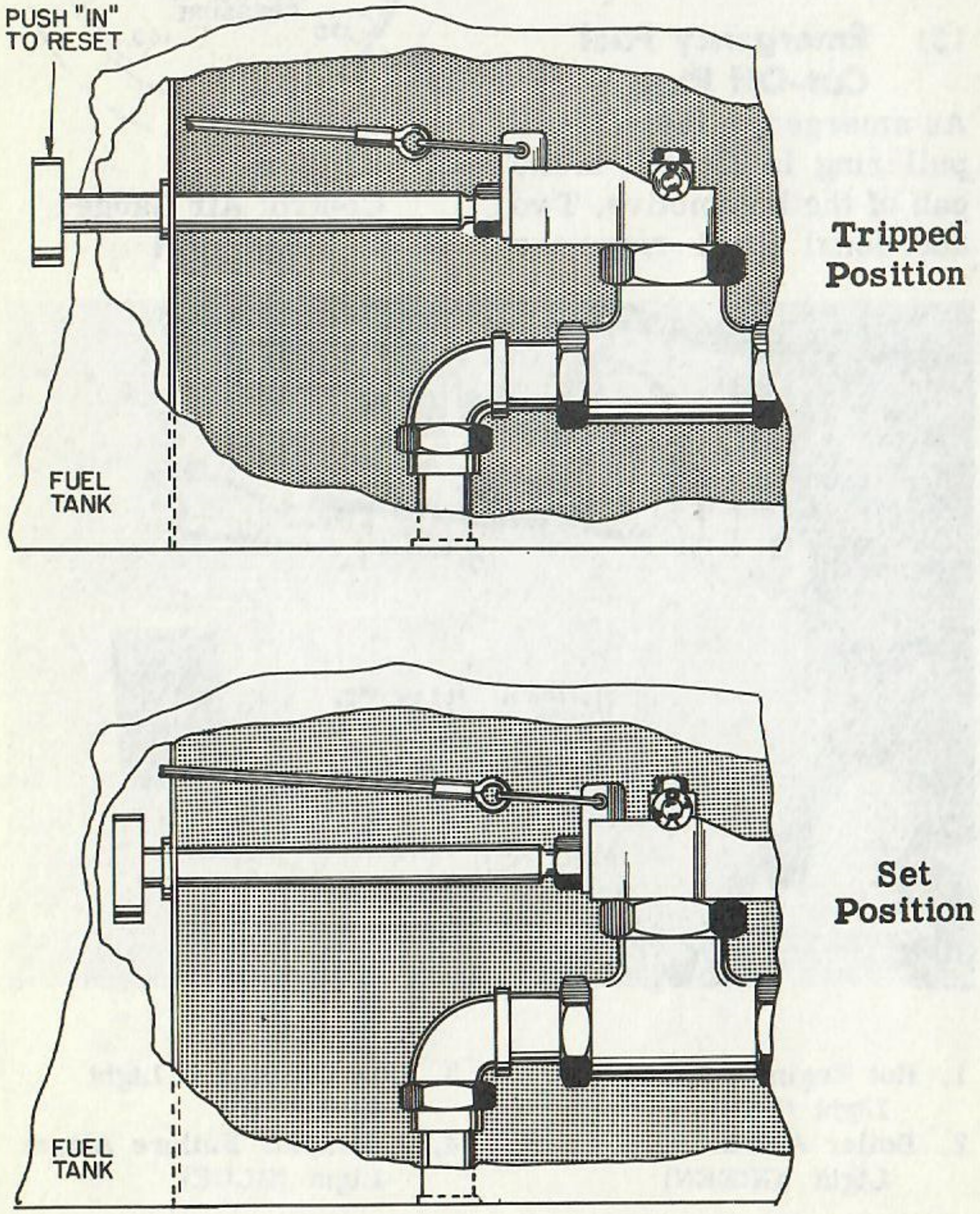
An emergency fuel cut-off pull ring is located in the cab of the locomotive. Two additional pull rings are



1. Hot Engine Alarm Light (RED)
2. Boiler Alarm Light (GREEN)
3. Low Oil Alarm Light (YELLOW)
4. Alternator Failure Alarm Light (BLUE)

Alarm Indications
Fig. 1-25

located one on each side of the locomotive adjacent to the fuel filler pipe. Pulling any one of the three emergency pull rings will trip the emergency fuel cut-off valve, stopping fuel supply to fuel pump. The valve is located on the underside of the fuel tank on the left side of locomotive. To reset, push valve control rod IN, Fig. 1-26.


PUSH "IN"
TO RESET
Tripped
Position
FUEL
TANK
Set
Position
FUEL
TANK

Emergency Fuel Cutoff Valve
Fig. 1-26

## ENGINE ROOM

The two ends of the engine are designated FRONT and REAR as shown in Fig. 1-27, which will serve to identify the cylinder locations, ends and sides of the engine, as they are referred to in this manual. The governor, water pumps, and lubricating oil pumps are on the FRONT END. The blowers, oil separator and the generator are mounted on the REAR END.

The engine is placed so that its rear end is toward the front end of the unit when the unit is operating in its normally forward direction.

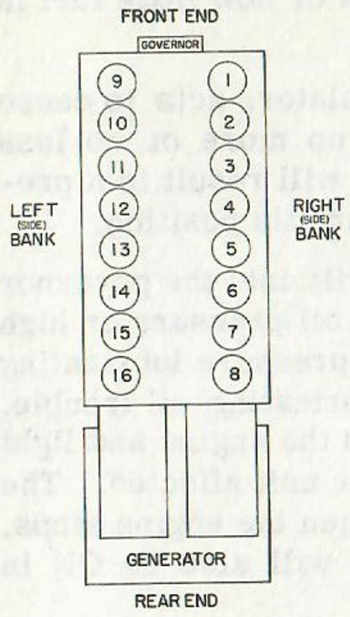
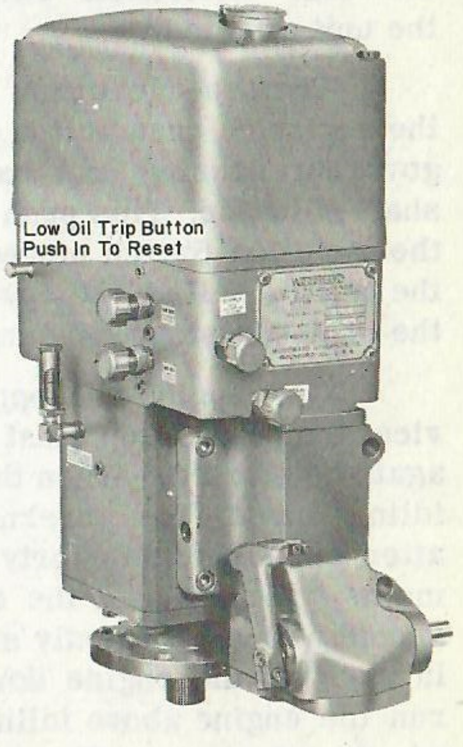

FRONT END
GOVERNOR
9
10
11
12
13
14
15
16
1
2
3
4
5
6
7
8
LEFT (SIDE) BANK
RIGHT (SIDE) BANK
GENERATOR
REAR END

Fig. 1-27

### 132 Engine Governor

The governor, Fig. 1-28, on the front end of the engine, performs the function of controlling the speed of the Diesel engine, as directed by the position of the throttle at the control stand. The speed of the engine is controlled from 275 RPM at Idle to 835 RPM in Run 8. The "orders" of the throttle are transmitted to the electro-hydraulic governor through electrical circuits. The governor is connected through a linkage


Low Oil Trip Button
Push In To Reset

Engine Governor
Fig. 1-28

to the injector control shafts on each bank of the engine. By regulating the position of the injector racks, and consequently the fuel injected to each cylinder, the speed of the engine is controlled. The governor performs its job of seeing that the engine rotates at the speed ordered by the throttle, regardless of how much or how little fuel is needed.

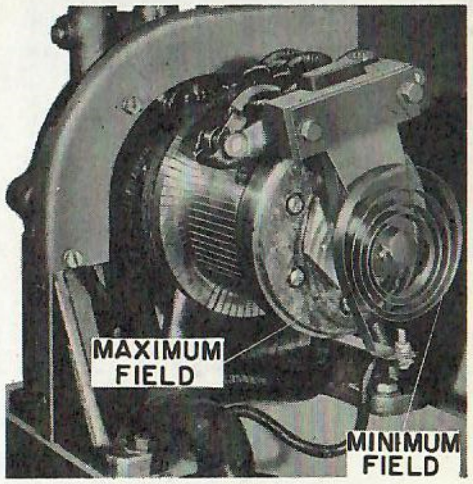
A device called the load regulator, acts to cause the governor to allow injection of no more or no less fuel to each cylinder than that which will result in a predetermined power output for each throttle position.

A low oil pressure device built into the governor protects the engine in case of low oil pressure or high vacuum on the suction side of the pressure lubricating oil pump. In the event of such lubricating oil trouble, the governor will immediately stop the engine and light the yellow low oil alarm signal in the unit affected. The alarm bell will ring in all units. When the engine stops, the "blue" Alternator Failure Light will also be ON in the unit affected.

When the governor low oil pressure device stops the engine, a push button protrudes from the front of the governor housing and exposes a red band around the shaft of button. This push button must be pressed IN and the Isolation Switch moved to START position to turn off the alarm bell. The low oil push button will not trip if the engine is stopped by any means other than oil trouble.

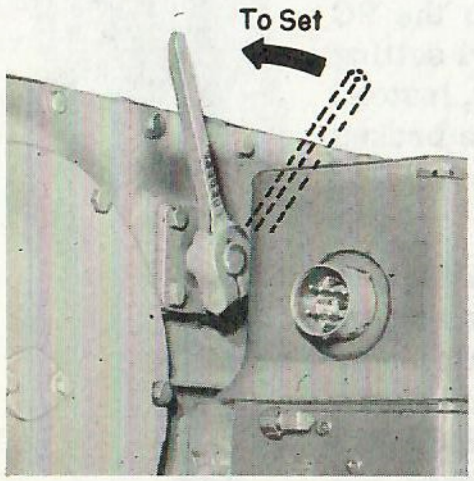
If an engine is stopped by the governor low oil device, the push button must be reset before the engine can again be started. When the engine is started and run at idling speed, the governor will again stop the engine after approximately forty seconds, if the condition remains which caused the original shutdown. The engine should not be repeatedly started if the governor persists in shutting the engine down. If an attempt is made to run the engine above idling speed during the delay period, the governor will immediately stop the engine if the oil pressure and suction are not normal.

133 **Load Regulator** The load regulator, Fig. 1-29, is located diagonally below the engine control panel. The primary purpose of the load regulator is to automatically control the loading of the engine by the main generator so that a predetermined power output is obtained for each position of the throttle. The load regulator is an automatically operated rheostat connected in series with the main generator battery field. (The main generator battery field is a low voltage externally excited field.)



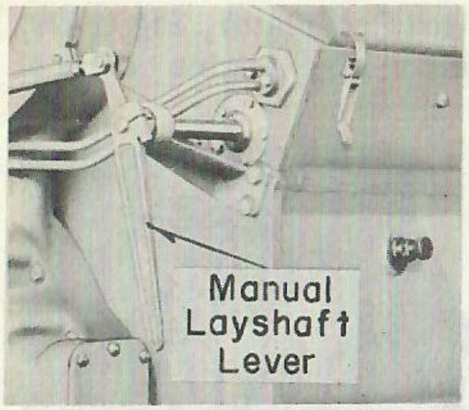
Load Regulator
Fig. 1-29

The load regulator is in minimum field when the brush arm, as viewed through the window, is in the four o'clock position. Maximum field is obtained with the brush arm in the eight o'clock position.



Engine Overspeed Trip
Fig. 1-30

134 **Engine Overspeed Trip** This device is located at the front end of the engine and will trip to bring the engine to a stop, if the engine speed should exceed approximately 910 RPM. Once this overspeed device is tripped, it must be reset manually (by pulling the lever counterclockwise until it latches) before the engine can again be started. See Fig. 1-30.



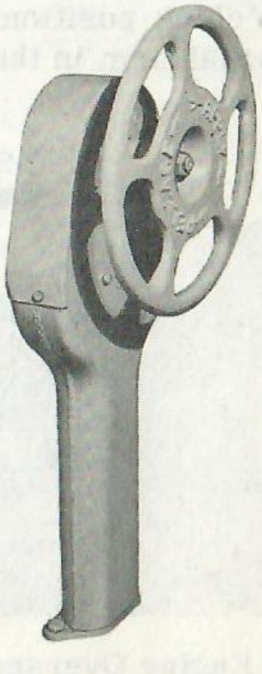
Manual Layshaft
Fig. 1-31

135 **Manual Layshaft** The manual layshaft control lever is attached to the end of the injector control shaft at the left front corner of the engine, Fig. 1-31. This lever may be used to manually shut down the engine, or to bring the speed to idle (as when taking an engine "off the line"). It is also used to facilitate the starting of a cold engine.

## MISCELLANEOUS EQUIPMENT

136 **Speed Recorder-Locomotive Overspeed Control** The speed recorder, located ahead of the controller, is a hydraulically operated speed indicator with a speed recording tape and an odometer. It is driven from the number 1 axle of the "A" unit, through a flexible cable. It contains a maximum speed device which will initiate a full service application of the brakes and trip the PC switch when the maximum speed setting is exceeded. On some railroads, instead of a full service application, the brakes go into emergency.

137 **Hand Brake** The hand brake, Fig. 1-32, is located against the side of the carbody near the air compressors in both "A" and "B" units. To set the brake, turn the wheel clockwise as far as it will go. To release the brakes, rotate the wheel counter-clockwise against the friction locks. Before moving the locomotive, be sure the brakes are completely released in all units. Whenever anyone is working around the locomotive trucks, the hand brakes should be applied.



Hand Brake
Fig. 1-32

138 **Manual Sanding Valve** When the locomotive is equipped with the hinged automatic brake valve handle, sanding is accomplished by depressing the lever beyond the safety control position previously described. This movement operates the sanding bail which opens a port to supply air to the sanding equipment. On locomotives having a rigid handle on the automatic brake valve, an independent sanding valve is provided.

139 **Classification Lights** A permanently fixed, clear bull's-eye is provided on each side of the locomotive nose section. Inside the nose section and behind each bull's-eye, a small compartment contains the classification light bulb and colored lenses. Red and green lenses are provided in each compartment which can be moved into position between the bulb and bull's-eye. To accomplish this, a locking pin is removed, the desired lens swung into place and the locking pin replaced. The lens box is accessible from inside the locomotive nose section. When both lenses are out of position the permanent bull's-eye lens will show a white light, thus making three colors available.

140 **Number Box Lights** Translucent number slides or burnt bulbs are changed from inside the nose compartment. The switch for these lights is located on the engineman's Push-Button switch box.

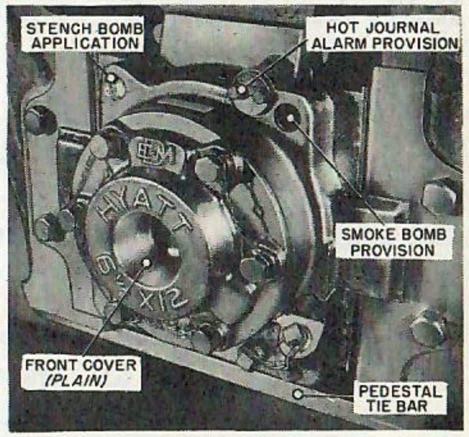
141 **Horn Valves** The horns (front and rear) are operated by air valves which are controlled by pull-cords, above the control stand. The horn shutoff valve, accessible from inside the nose compartment is located in front of the No. 2 main reservoir.

142 **Bell Ringer** The signal bell is under the locomotive floor behind the pilot on the left side. It is operated by an air valve located at the engineman's station. The bell shutoff valve, accessible from inside the nose compartment, is located to the left side of the front end of the No. 2 main reservoir.

143 **Windshield Wipers** The windshield wipers are controlled by valves, one of which is located on the engineman's instrument panel, and one on the panel on the fireman's side of the cab. These wipers operate independently of each other. The wipers should not be run on a dry window as they may scratch the glass.

144 **Cab Heaters and Defrosters** A cab heater is located on each side of the cab. Hot water from the engine cooling system passes through the heaters, and motor driven fans provide air circulation. The water flow to both heaters is controlled by a valve in the supply line, located above the left hand engine room steps. This valve must be kept wide open at all times in freezing weather. The heater output can be varied by use of the cab heater switches. The switches have four positions "OFF" 1, 2, 3, providing three different motor speeds. If the lead unit engine is shut down in freezing weather, steam, if available, may be admitted to the cab heaters.

Each side of the cab is equipped with a defroster motor and fan which blows heated air on the inside of the front cab windows. Both motors are controlled by the one defroster switch located on the engineman's Push-Button switch box.



Hyatt Journal Box
Fig. 1-33

145 **Trucks** Two four-wheel flexible trucks are provided on each locomotive unit. The outside swing hanger method of suspension, developed by EMD, provides increased stability on curves, better riding qualities, and reduced body roll.

The axles are all equipped with Hyatt roller bearing journal boxes. A stench bomb on each journal box will release a pungent odor if the temperature inside the journal box exceeds $220^{\circ}$ F., Fig. 1-33.

# SECTION 2

## OPERATION

The successful and dependable operation of the locomotive is dependent upon the quality of inspection and repair at regular maintenance periods, as well as the proficiency of the operating crews. As a supplement to terminal maintenance, a "pre-service check" should be made by the engine crew upon boarding the locomotive.

## BASIC INFORMATION

### 200 When Boarding the Locomotive

A. Ground Inspection - Locomotive Exterior and Running Gear

Check for:

1. Fuel oil, lube oil, water or air leaking from the locomotive.
2. Loose or dragging parts.
3. Proper positioning of angle cocks and shut-off valves.
4. Observe brake cylinder piston travel, if air brakes are set.
5. Condition of brake shoes.
6. Adequate fuel supply showing in fuel tank full length sight glass.
7. Drain condensate from main reservoirs.

B. Engineroom Inspection

In the engineroom with engines running, the following checks should be made (if engines are stopped, see Arts. 201 and 202 for starting instructions):

1. Lubricating oil supply.
   a. In Diesel engine oil pan.
   b. In engine governor.
2. Engine cooling water level in supply tank.
3. Air compressor lube oil pressure gauge.
4. Diesel engine lube oil pressure gauge.
5. Fuel flow in "fuel return" sight glass.
6. Check for oil, water and fuel leaks.
7. Drain condensation from air brake system.
8. Check position of controlled emergency cock on the D24 control valves in all "B" units. The position of the cock should correspond with the setting of the rotair valve in the operating cab either "FRGT" or "PASS."
9. Release hand brake in each unit.
10. Check all battery ammeters to see that the auxiliary generator in each unit is "charging." The ammeters should read "0" or a slight charge.
11. Place isolation switch in the RUN position.
12. In the electrical cabinets, all fuses must be securely in place and all knife switches should be closed.
13. Close air box drain valves.

C. Operating Cab Inspection

1. Check to see that the "Control and Fuel Pump" and "Engine Run" switches are pressed IN.

   NOTE: With older type units trailing in the locomotive consist, the "Engine Run" switch in the lead F9 or FP9 must be IN to keep the fuel pumps of those units running.
2. Place the throttle in IDLE, the reverse lever in neutral and the selector lever in No. 1 position.
3. Check position of the automatic and independent brake valves. Apply locomotive brakes.
4. Place brake pipe cut-out cock in "cut-in" or "open" position (handle horizontal).
5. Position rotair valve for service required. If the locomotive is to run light or haul a short freight train, the rotair valves in the operating and non-operating cabs should be placed in the PASS and PASS LAP positions, respectively; the controlled emergency cutout cock on the "B" unit control valves should also be placed in the PASS position. This insures a QUICK ACTING EMERGENCY on the locomotive.

   With long freight trains the above valves should be placed in FRGT LAP on the trailing "A" unit, and in FRGT on "B" units and the operating "A" unit. This will effect a CONTROLLED EMERGENCY action on each unit.

   The CONTROLLED EMERGENCY action CAN BE NULLIFIED (on the operating "A" unit only) if a quick acting emergency is desired, by simultaneously placing the independent and automatic brake valves in the full application and emergency positions, respectively.
6. If the locomotive has dynamic brakes, set the unit selector switch to correspond with the number of units in the consist (1, 2, 3 or 4).
7. Check battery ammeter.

D. Trailing Cab Inspection

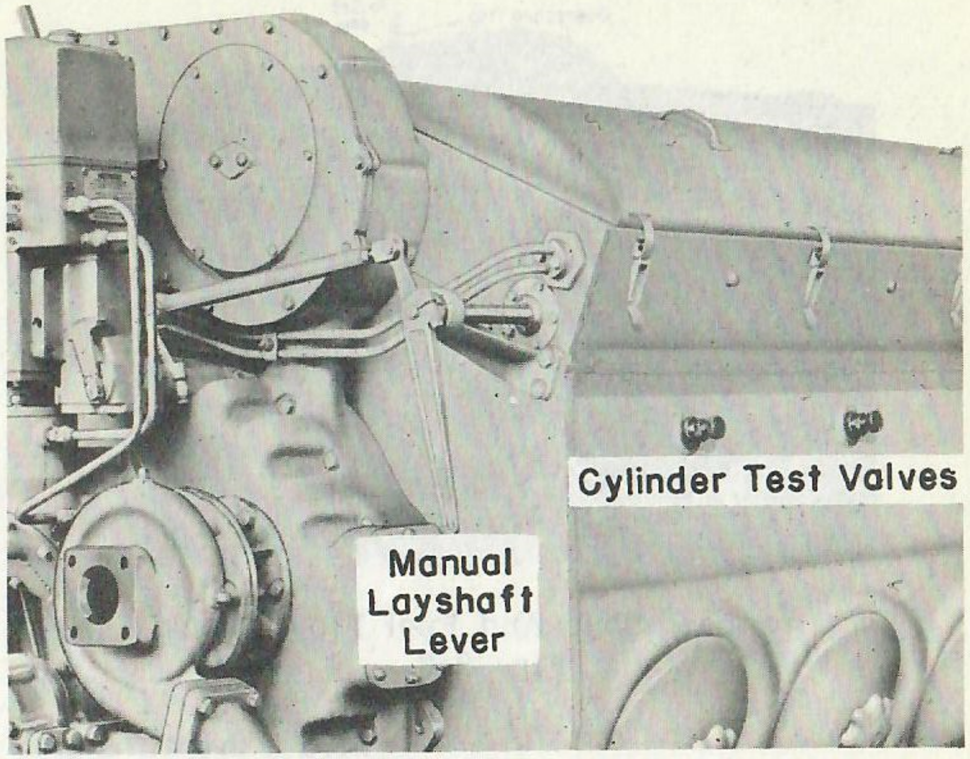
1. All switches on the engineman's Push-Button switch box should be OUT and locked.
2. Throttle lever should be in Idle, selector lever in OFF position and reverse lever removed from control stand.
3. Remove independent brake valve and removable automatic brake valve handles.
4. Position rotair valve in proper LAP position (PASS LAP or FRGT LAP corresponding to service of rotair valve in lead unit).
5. Place brake pipe cut-out cock in "cut-out" or "closed" position (handle vertical).
6. Check battery ammeter.

201 **Precautions Before Starting Engine** The following operations should be performed when an engine is to be started after a layover. If the engine has been stopped for a considerable period of time, the cylinders should be tested for fuel or water accumulation, as outlined in Item 10, before starting the engine.

1. With the locomotive stopped, place the independent brake valve in FULL application position.
2. Check position of all valves: Drains in cooling system, lube oil system and air reservoirs.
3. Check engine cooling water level.
4. Check lube oil supply:
   a. In Diesel engine oil pan.
   b. In engine governor.
   c. In air compressor.
5. Place the isolation switch in the START position.
6. In the electrical cabinet, on the distribution and low voltage panels, see that all the fuses are securely in place and that all knife switches are closed.
7. Remove the reverse lever from the controller.
8. At engineman's control station push IN the "Control and Fuel Pump" and "Engine Run" switches.

NOTE: When operating the F9 as a lead unit in multiple with older type units not equipped with an "Engine Run" push button switch, the "Engine Run" switch on the lead F9 or FP9 must be pressed IN to start and keep the fuel pumps of the trailing older type units running.

9. Check the PCS light; it should be OUT.
10. Test for water accumulation in engine cylinders.
   a. Remove 400 ampere starting fuse.
   b. Open all cylinder test valves (3 full turns), Fig. 2-1.
   c. Rotate engine at least one complete revolution by use of the engine turning jack.

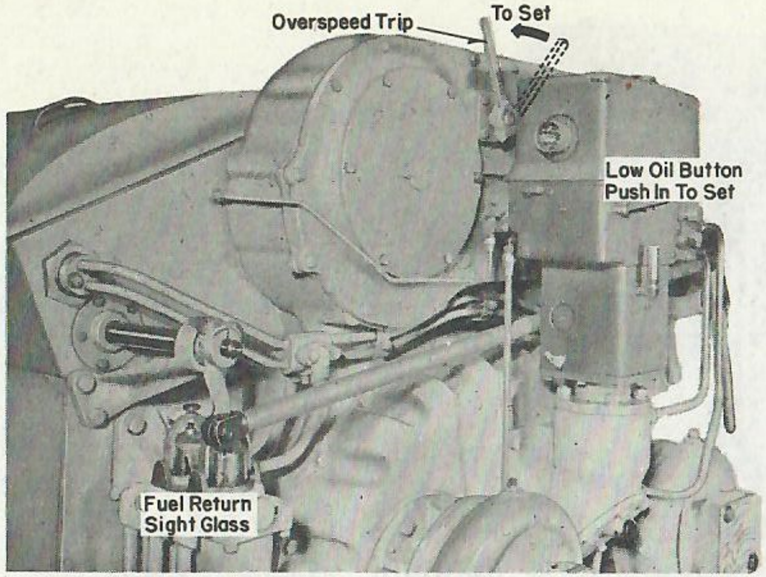


Cylinder Test Valves
Fig. 2-1

   d. Watch the cylinder test valves while engine is being rotated. If water is discharged from any test valve, do not attempt to start the engine until the cause of the water accumulation has been corrected.
   e. Close cylinder test valves.
   f. Replace 400 ampere starting fuse.

### 202 To Start Engine

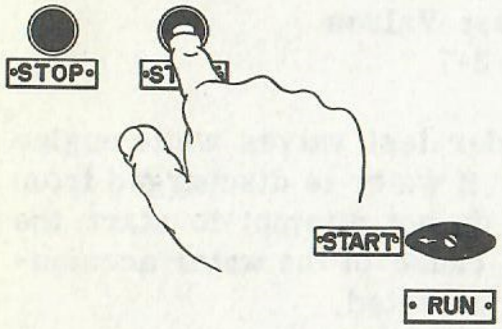
1. Check for fuel flow through "return fuel sight glass" on fuel filter mounted on the front of the engine, Fig. 2-2.
2. Check position of overspeed trip.
3. Check position of governor low oil trip button.
4. With the isolation switch in the START position, firmly press IN the engine START button and



Overspeed Trip And Fuel Flow Check
Fig. 2-2

hold it in until engine completely starts (not over 15 seconds), Fig. 2-3.

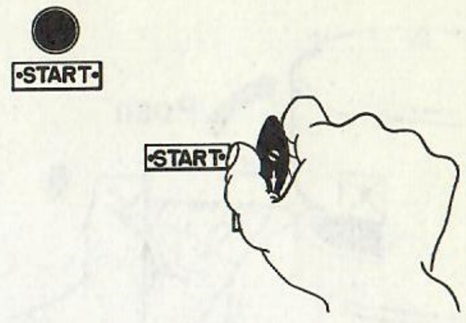
5. After the engine is started, check lube oil pressure.
6. Check ground relay.
7. Idle the engine until water temperature becomes normal.
8. See Section 3 if trouble is experienced in starting the engine.



Starting Engine
Fig. 2-3

**203 Placing An Engine On The Line** Before the engineman can control the speed of the engine with the throttle lever, the engine must be placed "on the line," and the "Engine Run" switch on the Push Button switch box must be pressed IN.

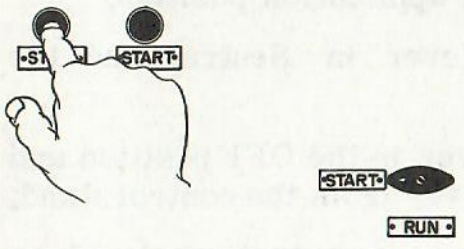
1. After the oil pressure has built up, the engine is placed "on the line" by merely placing the isolation switch in the RUN position, Fig. 2-4.
2. If an engine has been taken off the line for any reason, DO NOT place it "on the line" if the locomotive is being operated in dynamic braking.



Placing Engine On-the-Line
Fig. 2-4

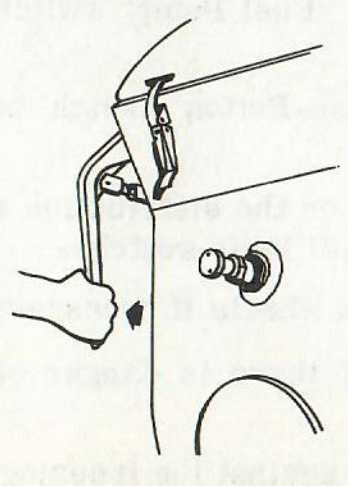
**204 To Stop Engine** There are three ways of stopping the engine, which can be designated as (1) normal, (2) under power and (3) emergency.

1. Normally stopping an engine applies when the locomotive is standing still. In this case the isolation switch is placed in the START position and the STOP button on the engine control panel is pressed IN until the engine stops, Fig. 2-5.

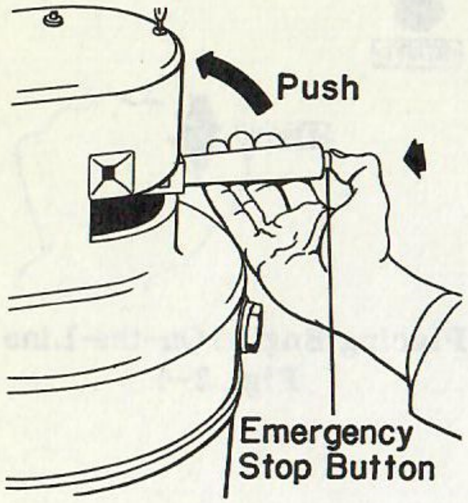


Stopping Engine
Fig. 2-5

2. Under power, in dynamic braking, or whenever necessary, an engine can be taken "off the line" by pulling the engine manual layshaft closed until the engine stops, Fig. 2-6. After stopping the engine, place the isolation switch in the START position.



To Stop Engine
Fig. 2-6



To Stop Engine
Fig. 2-7

3. In an emergency all engines "on the line" are simultaneously stopped by depressing the emergency stop button on the end of the throttle lever, Fig. 2-7, and pushing the throttle lever as far forward as possible to the STOP position.

## 205 Securing Locomotive for Layover

1. Place independent brake valve handle in FULL application position.
2. Place the reverse lever in Neutral and the throttle in Idle.
3. Place the selector lever in the OFF position and remove the reverse lever from the control stand.
4. In each unit, at the engine control panel, place the Isolation Switch in the START position and press in on STOP button until engine stops. When engine stops, place "Fuel Pump" switch in "OFF" position.
5. At the engineman's Push-Button switch box, pull OUT all switches.
6. In the electrical cabinet, on the distribution and low voltage panels, open all knife switches.
7. Set hand brakes and block wheels if necessary.
8. Cover exhaust stacks, if there is danger of a severe rain.
9. Take proper precautions against the freezing of the cooling system water in cold weather, see Art. 221.

# HANDLING LOCOMOTIVE

## 206 Precautions Before Moving Locomotive

1. NEVER move a locomotive, under its own power, without having first observed proper application and release of the brake shoes.
2. Check the main reservoir and the control air pressures.
3. Release hand brakes and remove any blocking of the wheels.
4. Engine water temperature should be normal.

**207 Handling Light Locomotive** With the engines placed "on the line" and cab preparations completed the locomotive is handled as follows:

1. Push IN "Generator Field" switch.
2. Insert and move the reverse lever to the desired direction. (This lever is to be moved ONLY when the locomotive is standing still.)
3. Place the selector lever in the No. 1 position.
4. Depress safety control foot pedal (if used).
5. Release the air brakes.
6. Open throttle a notch at a time. USE CAUTION. Throttle movement on the F9 is not mechanically restricted to one notch at a time.
7. Note that the locomotive rolls freely — care should be used in judging the speed.
8. The throttle must be in IDLE before coming to a dead stop.

## 208 Coupling To Train and Pumping Up Air

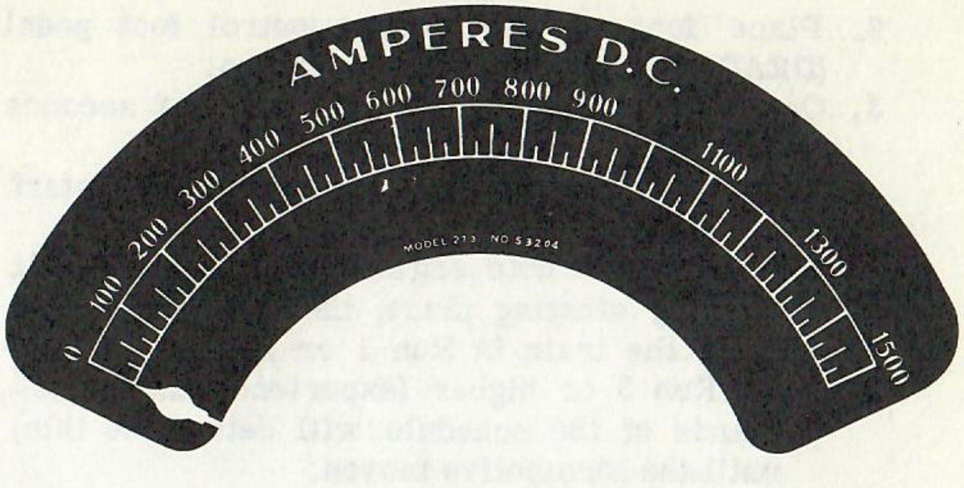
1. Locomotive should not be moved with air hoses hanging free on nose of "A" units.
2. In backing onto a train it may be desirable to use the attendant's call in rear "A" unit or train

signal whistle valves at rear of "A" and "B" units for signalling.

3. Valves and cocks.
   a. Nose angle cock is behind pilot on fireman's side.
   b. Steam line valve is behind pilot on engineman's side (pilot plate must be removed to connect steam line).
   c. The trainline signal whistle cutoff cock in the nose compartment is on the signal line reducing valve at the front of air brake rack.
4. After coupling to a train, stretch coupling to make sure it is properly made. If main reservoir pressure falls below feed valve setting when brakes are cut in, proceed as follows:
   a. PULL OUT "Generator Field" switch.
   b. Place reverse lever in neutral.
   c. Open throttle to 4th, 5th or 6th notch as needed.

209 **Starting a Train** Starting a train depends not only on the kind of locomotive being used, but also on the type, length, weight, grade, weather conditions and the amount of slack in the train. Because of the locomotive's very HIGH STARTING TRACTIVE EFFORT it is important that the air brakes be COMPLETELY released before attempting to start the train. Actual tests have shown that a 100 car train, having the average uniformly distributed leakage, may require 9 minutes to completely release the brakes. It requires approximately 30 minutes (with 130 pound main reservoir pressure) to completely charge a depleted air system on a similar 100 car train.

The load indicating meter, Fig. 2-8, can be used as a PULL METER to judge the tractive effort of the locomotive. Merely looking at the ground and listening to the engine exhaust may give a false indication of the locomotive's draw bar pull.



Load Indicating Meter
Fig. 2-8

The F9 locomotive is designed to have a COMPARATIVELY RAPID YET SMOOTH BUILD UP OF POWER. Load regulator timing is quite fast in moving from minimum to maximum and somewhat slower from maximum to minimum. This is due to a special design pilot valve bushing in the governor.

With this arrangement a power build-up equal to the throttle position is very quickly obtained. Any further advancement of the throttle is accompanied by an almost immediate additional increase in power. This may be seen by observing the speed with which the load indicating meter responds to throttle advance.

With a power control of this type the rate and extent of power build-up is left largely to the desire of the engineman yet is still controlled by the load regulator and engine governor.

When ready to start, the following general procedure is recommended:

1. Place the selector lever in the No. 1 position and move the reverse lever to the desired direction.

2. Place foot on the safety control foot pedal (DEADMAN) and release the brakes.
3. Open the throttle one notch every 1 to 2 seconds as follows:
   a. To Run 1 - note the load meter pointer start moving to the right.
   b. To Run 2 - note engine speed increase. At an easy starting place, the locomotive may start the train in Run 1 or 2.
   c. To Run 3 or higher (experience and the demands of the schedule will determine this) until the locomotive moves.
4. Reduce throttle one or more notches if acceleration is too rapid.
5. After the train is stretched, advance throttle as desired.

NOTE: If the wheel slip indicator flashes continuously, reduce the throttle one notch. Apply sand as needed to prevent further slipping and reopen the throttle when rail conditions improve. See Art. 210 - Automatic Sanding In Power.

Although it will generally be unnecessary to take slack in starting, there will be cases where it is wise to do so after making sure that all brakes are released. The throttle should be opened one notch at a time, in starting the train. A TONNAGE TRAIN SHOULD BE STARTED IN AS LOW A THROTTLE POSITION AS POSSIBLE, BEARING IN MIND THAT THE SPEED OF LOCOMOTIVE MUST BE KEPT AT A MINIMUM UNTIL THE TRAIN HAS BEEN STRETCHED. Sometimes it is advisable to reduce the throttle a notch or two the moment the locomotive begins to move, in order to prevent stretching the slack too quickly. The engineman must be the judge of the acceleration and the conditions under which the train is being started.

When the locomotive has moved far enough to completely stretch the train, the throttle may be advanced as quickly as desired, but should not be advanced so quickly that slipping results. Smooth acceleration is obtained by opening the throttle one notch each time the pointer of the load meter begins moving to the left.

210 **Automatic Sanding in Power** F9 locomotives are equipped with automatic sanding in power to assist in controlling wheel slip. When operating in transition one (1) (as in starting a train) sanding automatically takes place while slip is in its "creep" or initial stage. In this manner a wheel slip is "anticipated" and prevented before any appreciable loss of tractive effort occurs.

In transition 2, 3, and 4 (and on some occasions in transition 1) automatic sanding, caused by wheel slip, is accompanied by a reduction in main generator output.

Duration of sanding, after the wheel slip or creep has stopped, is controlled by the setting of a time delay sanding (TDS) relay. An "Automatic Sanding" switch on the engineman's Push-Button switch box cuts in or out this sanding-in-power feature.

With the automatic sanding feature "cut in" ("Auto.-Sand." switch pressed IN) throttle reduction to avoid repeated wheel slip will rarely be necessary. Also, manual operation of the sanders by the engineman at points on the road where slippage is likely to occur can be eliminated.

211 **Acceleration of a Train** After the throttle is in the 8th notch and the train begins to accelerate, the indicating meter pointer will move slowly to the left. Forward and backward transition will automatically take place without any attention on the part of the engineman, other than necessary throttle reductions to keep under any speed restriction.

212 **Slowing Down Because of a Grade**

1. As the train slows down on a grade the pointer on the indicating meter will move slowly toward the right. Backward transition will take place automatically.

213 **Locomotive Operation At Very Slow Speeds** The operation of an F9 locomotive, regardless of gear ratio, is not governed by any specific short time ratings.

In most cases, the locomotive may be operated up to the limit of the adhesion attainable.

F9 locomotives pulling tonnage trains at very slow speeds should be operated with the throttle in Run 8 position. In the event of a wheel slip indication (wheel slip light flashes on), the locomotive wheel slip control system will automatically apply sand to the rails (automatic sanding feature "cut in") and reduce the power to a point where slipping stops. If continuous wheel slipping on sand occurs, due to unusual rail operating conditions, the throttle can be reduced. Under these circumstances, the F9 locomotive can operate at reduced throttle, provided it is not necessary to reduce below the 5th throttle position to correct for a continuous wheel slip.

If there are any questions about an unusual operation of the locomotive, such as a passenger locomotive operating in freight service, Electro-Motive will, upon request, analyze the actual operation and make specific recommendations.

## BRAKING

214 **Air Braking With Power** The method of handling the air brake equipment is left to the discretion of the individual railroad. However, when braking with power it must be remembered that for any given throttle position the draw bar pull rapidly increases as the train speed decreases. This pull might become great enough to part the train unless the throttle is reduced as the train speed drops. Since the pull of the locomotive is indicated by the amperage on the load meter, the engineman can maintain a constant pull on the train during a slow down, by keeping a steady amperage on the load meter. This is accomplished by reducing the throttle a notch whenever the amperage starts to increase. It is recommended that the independent brakes be kept fully released during power braking. The throttle MUST be in Idle before the locomotive comes to a stop.

## MISCELLANEOUS OPERATING INSTRUCTIONS

215 **Multiple Unit Operation** In operating F9 units in multiple with each other or with other F type units, the operating controls of the locomotive are set up as outlined in Art. 217. When set up for multiple unit operation, the following precautions should be observed.

If the units of the consist are of different gear ratios, the locomotive should not be operated at speeds in excess of that recommended for the unit having the lowest maximum permissible speed.

If some of the units in the consist have an overload short time rating, the locomotive operation should be governed by the overload short time rating of the unit having the highest maximum permissible speed.

When "F" type units not equipped with automatic transition are operated in multiple with an F9 as the lead unit, the selector lever must be moved to effect forward and backward transition on these units. Movement of the selector lever to effect manual transition is made with reference to the locomotive speed, depending on the gear ratio of the unit or units being operated manually, see table below. The throttle should be reduced to the 6th notch when moving the selector lever from 2 to 3 or 3 to 2. Movement of the selector lever in the F9 lead unit does not effect transition on that unit or any other units in the consist equipped with automatic transition.

### MANUAL TRANSITION SPEEDS

| From | To | GEAR RATIO | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pos. | Pos. | 65/12 | 62/15 | 61/16 | 60/17 | 59/18 | 58/19 | 57/20 | 56/21 |
| 1 | 2 | 15 | 19 | 21 | 23 | 24 | 26 | 28 | 30 |
| 2 | 3 | 19 | 25 | 27 | 29 | 31 | 34 | 36 | 39 |
| 3 | 4 | 40 | 52 | 57 | 61 | 66 | 71 | 75 | 81 |
| 4 | 3 | 40 | 52 | 57 | 61 | 66 | 71 | 75 | 81 |
| 3 | 2 | 19 | 25 | 27 | 29 | 31 | 34 | 36 | 39 |
| 2 | 1 | 15 | 19 | 21 | 23 | 24 | 26 | 28 | 30 |

When the "F" type unit not equipped with automatic transition is operated as the lead unit in the consist, manual transition should be effected by moving the selector handle in accordance with the load meter indications. Automatic transition, in trailing units so equipped, will take place automatically without reference to the movement of the selector handle.

### 216 **Uncoupling and Coupling Units in Locomotive**

1. Take down all jumper cables between units.
2. Close angle cocks on both units on all air hoses.
3. Break hoses and separate units by uncoupling.
4. In coupling units:
   a. Couple and stretch units to insure couplers are locked.
   b. Connect hoses and jumpers and be sure all angle cocks on all air hoses are opened in both units.

   c. In any non-operating cab, cut-out the brakes and pull OUT and lock all the switches on the engineman's Push-Button switch box. Remove the reverse lever from the controller in all trailing units.

### 217 **Changing Operating Ends**

When the consist of the locomotive includes two "A" units, the following procedure should be followed in changing from one operating end to the opposite end:

1. If the locomotive is equipped with electro-pneumatic brakes and the brake has been in use, change the brake selector on the automatic brake valve to "AUTO" and open electro-pneumatic brake switch.
2. REMOVE REVERSE LEVER.
3. With safety control foot pedal depressed, make an automatic 20 pound brake pipe reduction.
4. Move the independent brake valve handle to release position; observe that the locomotive brakes are still applied.
5. Release safety control foot pedal.
6. Close brake pipe cut-out cock (handle vertical).
7. Move rotair valve to "Passenger Lap" or "Freight Lap" depending on service required.
8. Move the automatic brake valve handle to the RUNNING position and remove the handle from the brake valve.
9. Remove the independent brake valve handle in the RELEASE position.
10. PULL OUT all switches in engineman's Push-Button switch box and lock switches in OUT position.
11. Proceed to cab at opposite end. Check PC switch and reset if necessary.
12. Open switch lock on engineman's Push-Button switch box. Push IN "Control and Fuel Pump" and "Engine Run" switches, and any other switches that are necessary.

13. Insert reverse lever, automatic brake valve and independent brake valve handles.
14. Move the rotair valve to the "FRGT" or "PASS" position, depending upon the service desired.
15. Place the independent brake valve handle in the FULL application position.
16. Open brake pipe cut-out cock (handle horizontal), slowly, pausing from five to ten seconds in mid position.
17. Place unit selector switch in proper position if locomotive is equipped with dynamic braking.
18. When ready to move locomotive, depress safety control foot pedal or automatic brake valve handle and move the independent brake valve to RELEASE position.

NOTE: The "controlled emergency cock" on the control valve section in all "B" units should be placed in "Freight" (F) or "Passenger" (P) position to correspond to the rotair valve position in the lead "A" unit.

## 218 Handling Locomotive Dead-In-Train

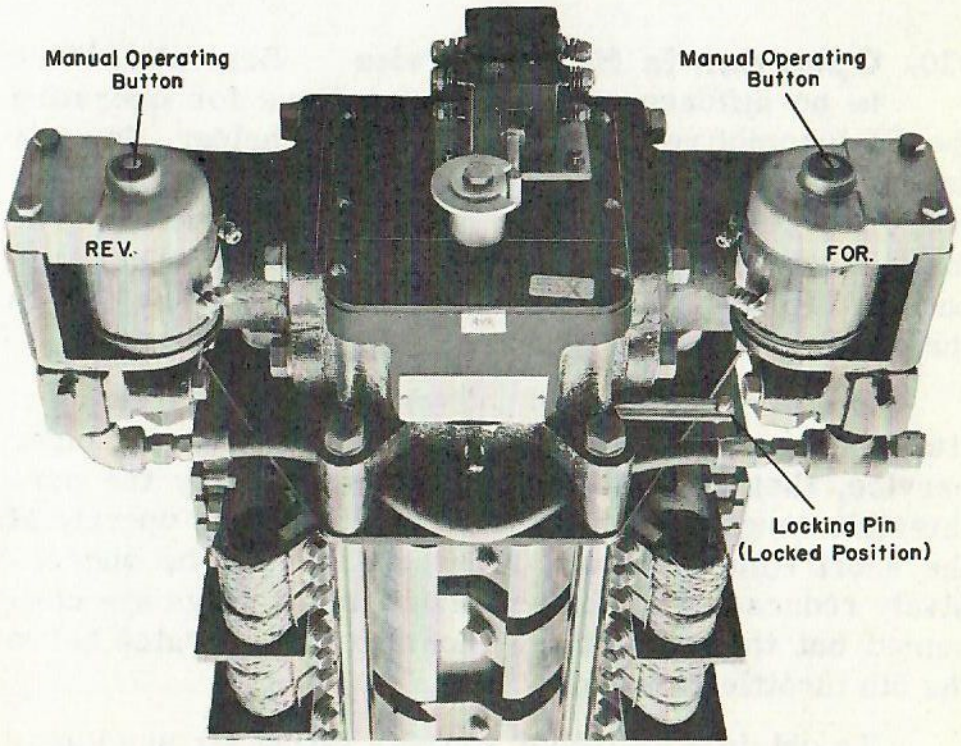
1. Air brake equipment.
   - a. Place the independent and automatic brake valve handles in the Release and Running positions respectively.
   - b. Close the brake pipe cut-out cock (handle vertical).
   - c. Open the dead engine cut-out cock.
   - d. Move the rotair valve to the passenger (PASS) position.

The locomotive brake will now operate like that of a car in the train.

2. Electrical control equipment.
   - a. Remove the reverse lever from the controller.

   - b. Place the isolation switch in the START position. If it is necessary to keep the engine idling for any reason while towing locomotive, the "Control and Fuel Pump" and "Engine Run" switches on the engineman's Push-Button switch box should be left pressed IN.
   - c. If locomotive is to be hauled in a train any appreciable distance, reverser switch, Fig. 2-9, should be placed in Neutral and locked in that position. Center the reverser drum switch in neutral by manually operating the forward and reverse magnet valve buttons.

To lock the reverser switch in neutral, remove the locking pin which during normal operation is screwed into the left hand side of the reverser housing. With the reverser drum switch in neutral, insert pin into hole



Reverser Switch — Locked In Neutral
Fig. 2-9

in the right side of reverser housing. Push pin in all the way through the reverser switch shaft and screw pin into threaded hole.

219 **Doubleheading** Prior to doubleheading behind another locomotive, make a full service brake pipe reduction with the automatic brake valve and close the doubleheading cock. Leave the rotair valve in the "PASS" or "FRGT" position, depending on the type of service required. Return the automatic brake valve handle to the running position and place the independent brake valve in release position. The operation of the throttle is normal, but the brakes are controlled from the lead locomotive. The engineman on the second locomotive may make an emergency application of the brakes with the automatic brake valve, and/or may release his locomotive brakes by depressing the independent brake valve handle, in the release position.

220 **Operation In Helper Service** Basically, there is no difference in the instructions for operating the F9 locomotive as a helper or with a helper. In most cases, the F9 locomotive can be operated in either service up to the limit of the adhesion attainable. The throttle can be reduced to prevent excessive wheel slip, but the locomotive should not be operated below the 5th throttle position.

If other Diesel locomotives having overload short time ratings are used with the F9 locomotive in helper service, their operation will be governed by the permissible length of time the locomotives can operate at the short time ratings. The throttle must be successively reduced as the higher short time ratings are consumed but the locomotives should not be operated below the 5th throttle position.

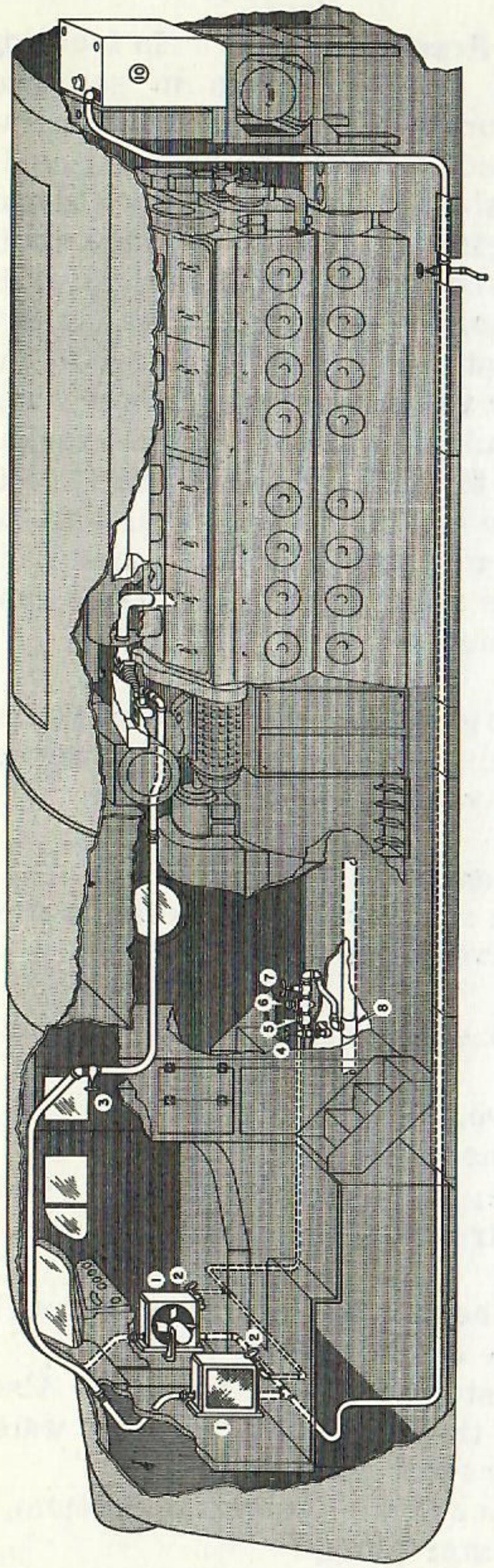
To obtain a maximum tonnage rating for any single application, Electro-Motive will, upon request, analyze the actual operation and make specific tonnage rating recommendations.

221 **Freezing Weather Precautions** In freezing weather, precautions must be taken to see that water in the locomotive does not freeze when the engine is shut down for any reason. If an "A" unit engine is shut down, but trainline steam is available, open steam admission valves into engine and "G" valve on the cooling water supply tank. The steam admission valve is located on engineroom floor at left front corner (governor end) of engine. Do not confuse this valve with the engine drain valve. Close valve 3 and open valves 2 and 7, Fig. 2-10. Valve 4 should be closed, valve 9 cracked open to allow condensate to drain. On a "B" unit it is only necessary to open the steam admission valve to the engine and the "G" valve to accomplish the same purpose. If trainline steam is not available, the entire system will have to be drained.

A. If the engine and steam generator are inoperative and steam from an external source is supplied to prevent freezing, the following valves are to be opened:

1. Engine cooling system.
    a. Steam admission valve to engine cooling water.
    b. Steam supply valve to cab heaters.
    c. "G" valve.
    d. Toilet water tank steam valve.
2. Steam Generator
    a. Heating coil valve.
    b. Water suction line valve.
    c. Water tank valve.
    d. For detailed instructions, see Section 6.

B. In freezing weather if heating facilities are not available, all water must be drained from:
1. Engine cooling system and cab heaters. Also, open the drain in the bottom of the right water pump housing to prevent its freezing.
2. Steam Generator (See Steam Generator Section).
3. Steam Generator Water Tank.
4. Toilet Water Tank.



Cab Heating System
Fig. 2-10

1. Cab Heaters
2. Cab Heater Steam Valves ⊕
3. Cab Heater Valve
4. Steam Heating Line Drain Valve ⊕
5. Check Valve
6. Steam Pressure Reducing Valve
7. Steam Admission Valve ⊕
8. Steam Trainline Connection
9. Cab Heater Drain Valve ⊕
10. Engine Cooling Water Tank

⊕ Normally Closed

5. "G" Valve.
6. Air System
   - a. Air compressor oil separator.
   - b. Sump reservoirs.
   - c. Main reservoirs.
   - d. Type H filter.
   - e. Electrical control air regulator.
   - f. Electrical control air reservoir.
   - g. Strainers at engine control and instrument panel, and electrical control cabinet.
   - h. Air compressor intercooler.

222 **Operation Over Railroad Crossings** When crossing railroad crossings, reduce throttle to the 5th notch before reaching crossing and leave reduced until all units are over crossing. This will reduce arcing from the brushes to the motor commutator.

223 **Running Through Water** Under ABSOLUTELY NO circumstances should the locomotive pass through water which is deep enough to touch the bottom of traction motor frames. When passing through water, always go at a very slow speed (2 to 3 miles per hour). Water any deeper than three inches above the top of the rails is likely to cause damage to the traction motors.

224 **Resetting PC Switch After Safety Control Application**

1. CLOSE THROTTLE TO IDLE.
2. Place automatic brake valve in LAP.
3. Place foot on safety control foot pedal.
4. Wait until application pipe is normal. Listen for exhaust or watch PCS light. If the PC switch does not reset itself with the automatic brake valve handle in LAP, move the brake valve handle to the RUNNING position. The PC switch is properly set when the light goes out.
5. Reset train control.
6. Release brakes.

225 **Ground Relay Action** Pointer points to yellow dot when set and to red dot when tripped. When the ground relay is tripped the engine will not speed up when throttle is opened and no power will be developed. If the ground relay trips, while the throttle is in Run 5 or 6, the engine will stop. To reset, isolate engine, depress relay reset button and put engine "on the line." If relay continues to trip, isolate unit.

226 **Wheel Slip Indication** The wheel slip light will flash on immediately when a pair of wheels has slipped. The detection of wheel slip action automatically reduces the application of power to stop the slipping; the power will be reapplied after the slipping has stopped.

It will generally be unnecessary to reduce the throttle because of momentary wheel slip action. Sand may be applied to prevent repeated wheel slipping which may occur under extremely poor rail conditions.

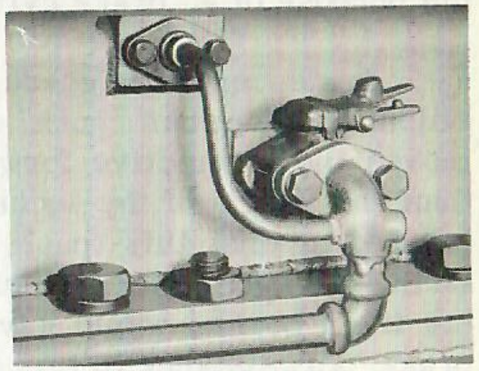
227 **Indication of a Pair of Wheels Sliding** If one pair of wheels should slide when starting a train, the wheel slip light will flash on and off intermittently. As the train speed increases, the light will stay on more or less continuously and will not go out when the throttle is reduced. The light will go out when throttle is closed to idle.

If sliding is suspected, the engine crew should make an immediate investigation to determine the cause. The wheels may be sliding due to a locked brake, a broken gear tooth wedged between the pinion and ring gear, etc.

Repeated ground relay action, accompanied with unusual noises such as continuous thumping or squealing, may also be an indication of serious traction motor trouble that should be investigated at once.

UNDER NO CONDITION OF REPEATED WHEEL SLIP OR GROUND RELAY ACTION SHOULD A POWER PLANT BE ISOLATED AND ALLOWED TO REMAIN IN THE CONSIST UNLESS IT IS CERTAIN THAT ALL WHEELS ARE ROTATING FREELY.

228 **Air Box Drains** The engine air box accumulation settles in two drain tanks incorporated in the engine oil pan near the generator end, one on each side. Two air box drain valves, Fig. 2-11, permit draining of these tanks. The tanks should be drained periodically when the locomotive is standing still. With the air box drain valves open, observe the drain pipe discharge under the locomotive to determine if there is any water or an excessive oil accumulation in the air box. If a discharge is observed from the drain pipes under the locomotive with the air box drain valves closed (accumulation flowing through overflow pipe), the air box accumulation should be investigated.



Air Box Drain Valve
Fig. 2-11

## OPERATION OF LOCOMOTIVE "EXTRAS"

F9 locomotives can on special order be equipped with dynamic brakes, motor lockout switches and hostler's controls.

229 **Dynamic Brake Operation** Dynamic braking is an electrical hookup used to change some of the power developed by the momentum of a moving locomotive into an effective holding brake. The traction motor armatures, being geared to the axles, are rotating whenever the train is moving. When using dynamic brake,

electrical circuits are set up which change the traction motors into generators. Since it takes power to rotate a generator, this action retards the speed of the train. The dynamic brake is, in effect, very similar to an independent brake, and the load indicating meter serves the purpose of a "brake cylinder pressure gauge."

In descending a grade, with the throttle in Idle position, the drawbar "push" of the trailing train tonnage moves the locomotive forward. If no resistance other than the weight of the locomotive and wheel friction is exerted against this "push," the momentum of the train on the descending grade would soon reach a speed where the train brakes would have to be applied. In dynamic brake, a resistance to this drawbar push is set up which in effect "holds back" the speed of the train as would the application of the locomotive independent brake. The effect of the resistance is to slow down the traction motor armatures being driven by the "push" of the train.

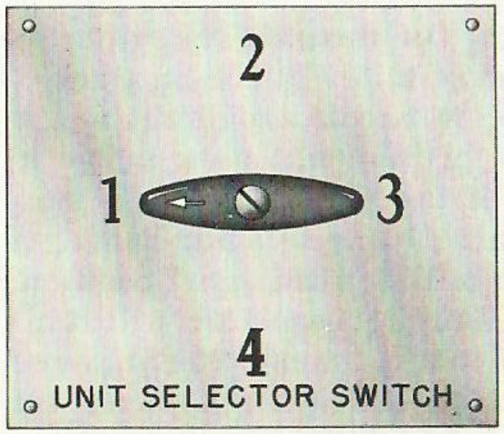
The resistance set up in each traction motor is a magnetic field through which the traction motor armature must rotate. Increasing the strength of the magnetic field will effect a "slow down" of the traction motor armature, thus holding back the train. The magnetic field is produced by connecting the traction motor fields of each unit in series with the main generator and passing a current through these fields. The strength of the magnetic field is varied by varying the main generator current to the traction motor fields in each unit.

The main generator battery field of each unit in the locomotive consist is connected in series to the low voltage supply of the lead unit. This is called the "field loop" circuit. Movement of the selector lever in the lead unit toward the "B maximum" braking position, increases the battery field excitation of each main generator, which in turn increases the main generator current to the traction motor fields. Thus, in effect, the strength of the magnetic field through which the traction motor armature must rotate, is controlled by the movement of the selector lever in the braking position. Moving the selector lever toward the "B maximum" position increases the effectiveness of the "holding brake."

In dynamic brake, the traction motor armatures are connected to grids located in the top of the carbody. Rotation of the armature through the magnetic field generates power (braking current) and this current flows through the grids to be dissipated as heat. The braking current generated increases as the armature rotation increases (momentum of train increases the drawbar push) or as the strength of the magnetic field is increased (engineman advances selector handle toward "B maximum" position). The maximum braking current that can flow through the grids is automatically limited to 700 amperes regardless of locomotive speed or selector lever position.

To operate the dynamic brake on locomotives so equipped, proceed as follows:

1. Position the unit selector switch, Fig. 2-12, in the lead unit to correspond to the number of units in the locomotive consist.
2. Reverse lever should be positioned in the direction of locomotive movement.
3. Throttle must be reduced to Idle.
4. Move selector lever from No. 1 to "Off" position; pause 10 seconds before proceeding to Step 5.
5. Move selector lever to the "B" position. (In the "B" position the dynamic braking



Unit Selector Switch
Fig. 2-12

circuits are partially established and depending on the speed of the train, enough braking may be present to bunch the slack. In this position, the brake transfer switch (BKT) is moved to the "brake" position. Movement of the "BKT" to "brake," disconnects the traction motor armatures from the motor fields and connects the armatures to the grids. The traction motor fields of each unit are connected to the main generator of that unit. The main generator battery field of each unit in the consist is connected in series to the low voltage supply of the lead unit, but the selector handle must be moved beyond the "B" position to excite this battery field circuit.

6. After slack is bunched, the lever may be moved farther to the right to give the desired amount of braking effort. (The speed of the diesel engine is increased from 275 r.p.m. (Idle) to 435 r.p.m. automatically as the selector handle is moved beyond the "B" position).
7. Observe the braking amperage (braking effort) on the load indicating meter. The braking amperage is automatically limited to a maximum braking effort of 700 amperes regardless of locomotive speed or selector handle position.
8. If maximum braking is desired, the selector handle should be moved to the full "B maximum" position. The selector handle should always be moved SLOWLY to prevent a sudden surge of current in excess of the maximum brake current rating. Generally, if the selector handle is moved slowly to the full "B maximum" position, the brake current limiting regulator will limit the braking current to a maximum 700 amperes and no brake warning indication of excessive braking current will be given. However, if the brake warning light flashes on, movement of the selector handle should be stopped until the light goes out.

If the light fails to go out after several seconds, move selector handle back toward "B" position slowly until the light does go out. After the brake warning light goes out, the selector handle may again be advanced slowly toward the full "B" maximum" position.

9. When necessary, the automatic brake may be used in conjunction with the dynamic brake. However, the independent brake must be KEPT FULLY RELEASED whenever the dynamic brake is in use, or the wheels may slide. As the speed decreases below 10 miles per hour the dynamic brake becomes less effective. When the speed further decreases, it is permissible to completely release the dynamic brake by placing the selector lever in the "OFF" or No. 1 position, applying the independent brake simultaneously to prevent the slack from running out.

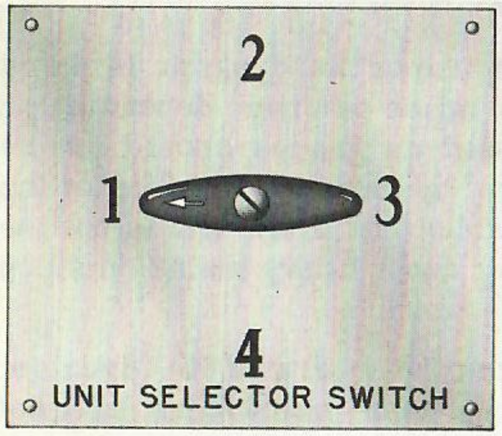
NOTE: The most effective use of the dynamic brake is between 15 and 25 miles per hour depending on the gear ratio. Speed on grades should not be allowed to "creep up" by careless handling of the brake, as this is a holding brake and is not too effective in slowing down heavy trains on steep grades.

F9 locomotives can be operated in dynamic braking coupled to older units that are not equipped with brake current limiting regulators. If all the units are of the same gear ratio, the unit having the lowest maximum brake current rating should be placed as the lead unit in the consist. The engineman can then operate and control the braking effort up to the limit of the unit having the lowest brake current rating, without overloading the dynamic brake system of a trailing unit. The locomotive consist MUST always be operated so as not to exceed the braking current of the unit having the lowest maximum brake current rating.

Units equipped with dynamic brake current limiting regulators can be operated in multiple with F9 locomotives in dynamic braking regardless of the gear ratio, or difference in the maximum brake current ratings.

Units not equipped with dynamic brake current limiting regulators and of different gear ratios will require special operating instructions when used in multiple with an F9 locomotive in dynamic braking.

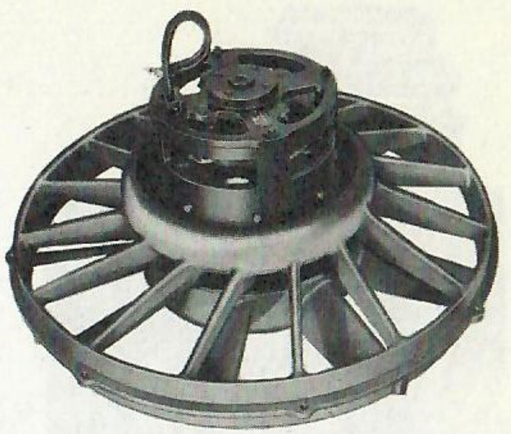
230 **Dynamic Brake Selector Switch** The dynamic brake unit selector switch, Fig. 2-13, located at the engineman's control station, has four positions (1, 2, 3 and 4) and should be set to correspond with the number of units in the locomotive consist. This switch should be set before leaving the terminal and must not be changed even if an engine is isolated enroute. This switch is changed only if the number of units in the locomotive consist is changed.



Unit Selector Switch
Fig. 2-13

231 **Dynamic Brake Warning Light** The dynamic brake warning light on the engineman's instrument panel will flash on when an excessive braking current is developed. Generally, the over-current is only temporary, and the dynamic brake current limiting regulator will automatically reduce the braking current to a maximum 700 amperes.

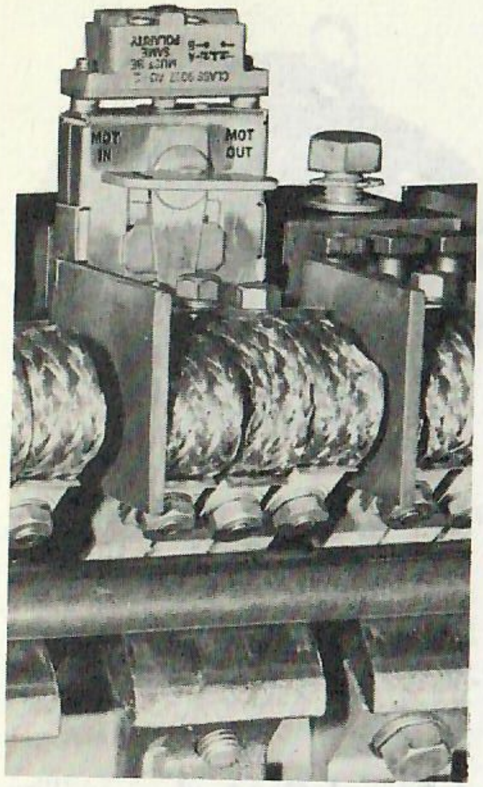
232 **Dynamic Brake Grid Blower** The braking current, generated by the traction motors in dynamic braking, flows through the grids to be dissipated as heat. The grids are cooled by a motor driven fan, Fig. 2-14. The grids and fan are located in the top of the carbody above the main generator and air compressor. Power generated by the No. 1 and No. 3 traction motors drives the grid blower motor.



Dynamic Brake Grid Blower
Fig. 2-14

233 **Dynamic Brake Wheel Speed Control** The relays, used to correct a wheel slip while under power, are also used to correct the tendency of one pair of wheels to rotate slower while in dynamic braking due to an unusual rail condition.

When a pair of wheels is detected tending to rotate at a slower speed, the retarding effort of the traction motors in the unit affected is reduced (main generator battery field excitation is reduced in the unit affected) and sand is automatically applied to the rails ("Automatic Sanding" circuit breaker on engineman's control panel must be in "ON" position). When the retarding effort of the traction motors in the unit is reduced, the tendency of the wheel set to rotate at a slower speed is overcome. After the wheel set resumes normal rotation, the retarding effort of the traction motors returns (increases) to its former value. Automatic sanding continues for approximately 20 seconds after the wheel speed is corrected.



Motor Lockout Switch
Fig. 2-15

234 **Motor Lock-Out Switches** Four motor lockout switches (CO1, CO2, CO3, and CO4) are mounted on the reverser drum, Fig. 2-15. Each switch permits the isolation of the corresponding traction motor from the power circuit (CO1 cuts out traction motor No. 1) in the event that a traction motor is grounded. Always isolate the engine before opening a motor lockout switch. Not more than one traction motor should be cut out at any time, and the armature of the traction motor cut out must be free to rotate.

235 **Operating "B" Unit with Hostler's Controls** Operation at the hostler station is the same as an "A" unit. The push button switches are beside the controller. The brake valve cutout cock is below the brake valve. The bell valve is a globe valve near the controller. Only No. 1 transition is available. Movement of the reverse lever automatically places the locomotive in No. 1 transition. It should be remembered that the operation of the "B" unit controls will operate all units joined to it.

When securing the hostler control, be sure all push buttons are pulled out, the controller and reverser pinned, and the brake valve cut out, as these items can affect operation at any other station or cab.

# SECTION 3

## LOCATION AND CORRECTION OF DIFFICULTIES ON-THE-ROAD

This section provides a check list calling the operator's attention to the troubles which are most frequently encountered on the road, and which can be quickly remedied thereby eliminating many delays.

No attempt is made to explain general operation and functions of equipment on the locomotive. For such information refer to the other sections of this manual.

**300 General** Safety devices automatically protect the equipment in case of the faulty operation of most any component. In general, this protection is obtained by unloading or preventing the loading of the Diesel engine so that the locomotive loses its pulling power. The locomotive can lose its power with the Diesel engine still running or stopped. An exception if a hot engine alarm which does not reduce the engine load or speed.

When trouble is experienced, the general location and type of difficulty is often indicated by the ringing of an alarm bell and the lighting of one or more signal lights in the troubled units. The signal lights are as follows:

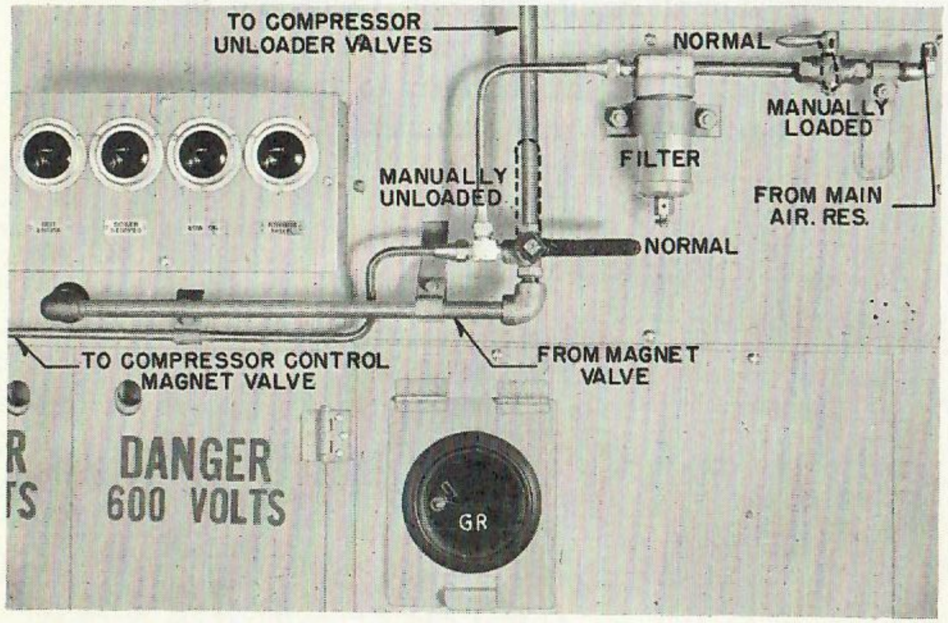
a. Hot Engine - RED
b. Boiler Stopped - GREEN
c. Alternator Failure - BLUE
d. Low Oil - YELLOW
e. PC Switch - WHITE

**301 If Alarm Bells Ring** One or more of the signal lights will be illuminated in the unit affected, Fig. 3-1.

**RED—Hot Engine** This alarm light indicates that the outlet engine water temperature is about 208° F. A hot engine alarm does not reduce the engine load or speed. The alarm signal will not stop until temperature returns to normal.

In case of hot engine alarm, proceed as follows:

1. Isolate engine. Isolating the engine will not stop alarm bell; temperature must return to normal.
2. Check engine cooling water tank for correct level, Fig. 3-2. If there is sufficient water in the system, allow engine to run at IDLE speed.

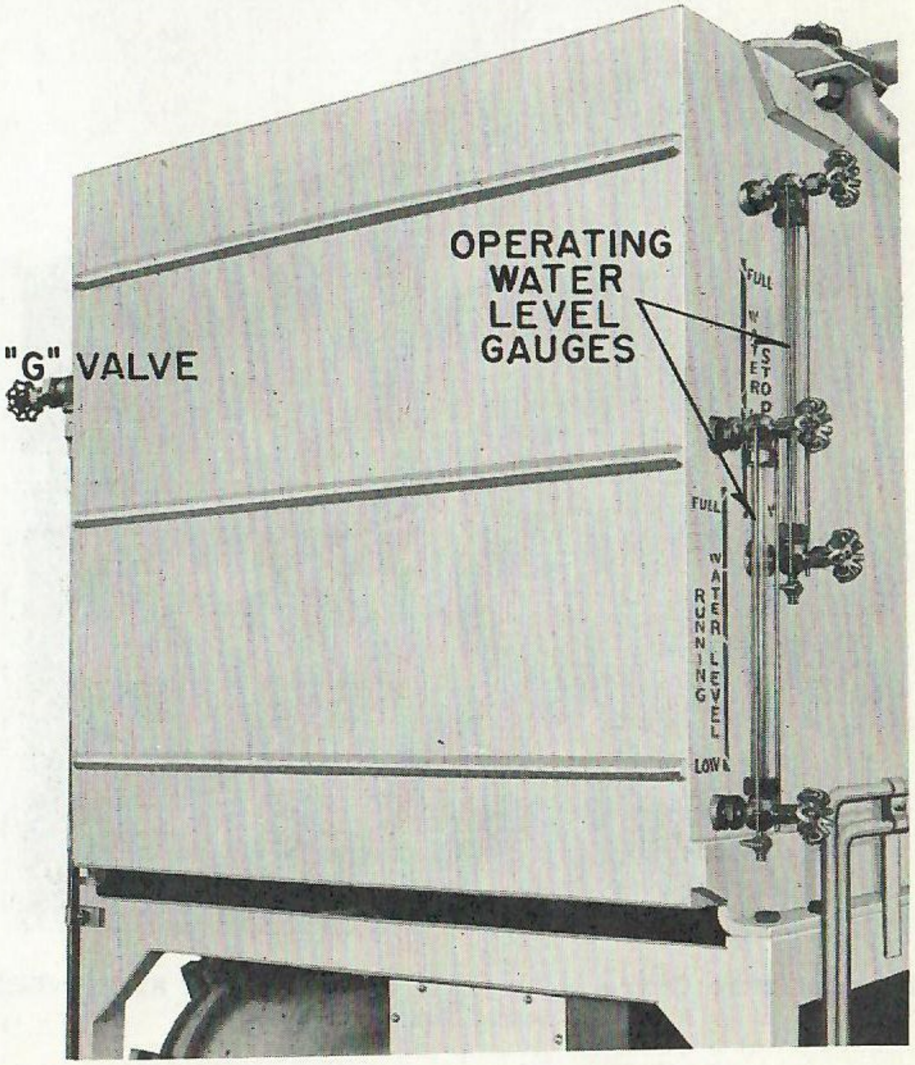

TO COMPRESSOR
UNLOADER VALVES
NORMAL
MANUALLY
LOADED
FILTER
MANUALLY
UNLOADED
FROM MAIN
AIR. RES.
NORMAL
TO COMPRESSOR CONTROL
MAGNET VALVE
FROM MAGNET
VALVE
DANGER
600 VOLTS
GR

Alarm Lights
Fig. 3-1

3. See that all AC cooling fan contactors are closed, Fig. 3-3.
4. See that the shutters are open. If closed, check position of "shut off" valve in the air supply pipe to the shutter magnet valve.
5. See that the "Control and Fuel Pump" switch is IN.

**GREEN—Boiler Stopped** Indicates steam generator has stopped. To stop alarm light and bell, turn boiler switch OFF, Fig. 3-4. To correct, see Steam Generator Trouble Shooting Chart Section 6.

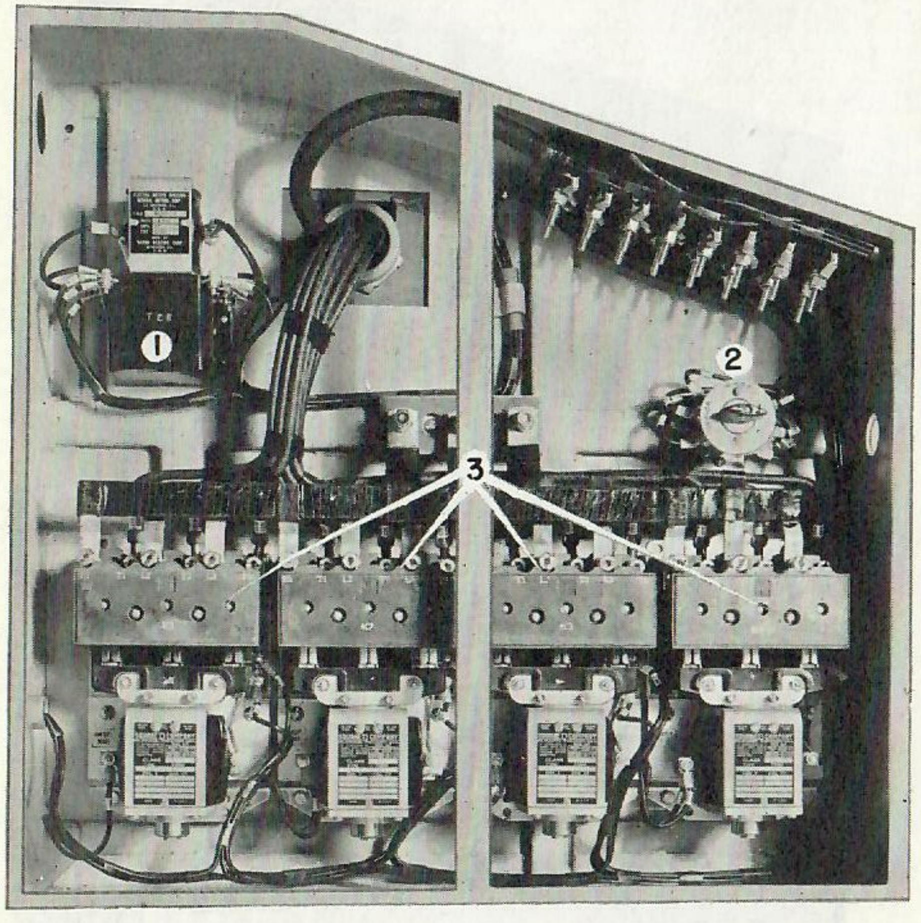
**BLUE—Alternator Failure** This alarm signal indicates that the alternating current system has failed; traction


"G" VALVE
OPERATING
WATER
LEVEL
GAUGES
FULL
FULL
RUNNING WATER LEVEL
LOW

Cooling Water Level
Fig. 3-2

motor blowers and radiator cooling fans have stopped; No Voltage Relay (NVR) is opened (de-energized), Fig. 3-5. The engine speed and load is automatically reduced equivalent to No. 1 throttle position. The engine will STOP if the "AC" system fails with the throttle in Run 5 or 6. Placing the isolation switch in START stops the alarm signals.

Most "Alternator Failure" alarms are "false" since this alarm occurs if the engine is stopped for any reason while "on the line." With and "Alternator Failure" alarm and the engine stopped, ALWAYS isolate and check cause of engine stopping. Check; overspeed trip, throttle must not be in STOP position; and fuel flow through fuel return sight glass, Fig. 3-6, before trying to start engine that has shut down with no indication other than an "Alternator Failure" alarm. If other alarm indications

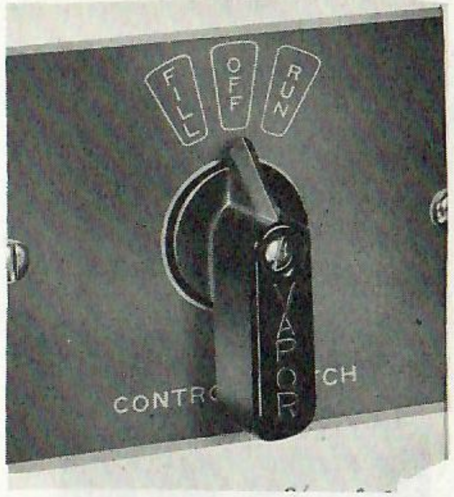


1. Temperature Control Relay 2. Summer-Winter Switch (SWS)
3. AC Cooling Fan Contactors

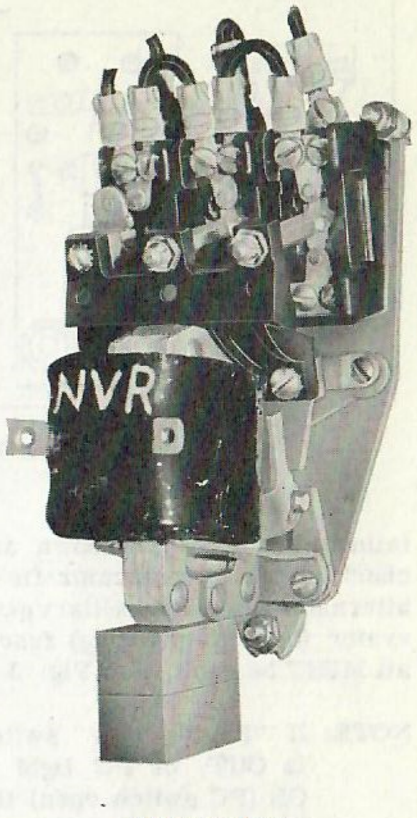
AC Contactor Panel
Fig. 3-3

are present with the "Alternator Failure" alarm, they must also be checked before starting the engine.

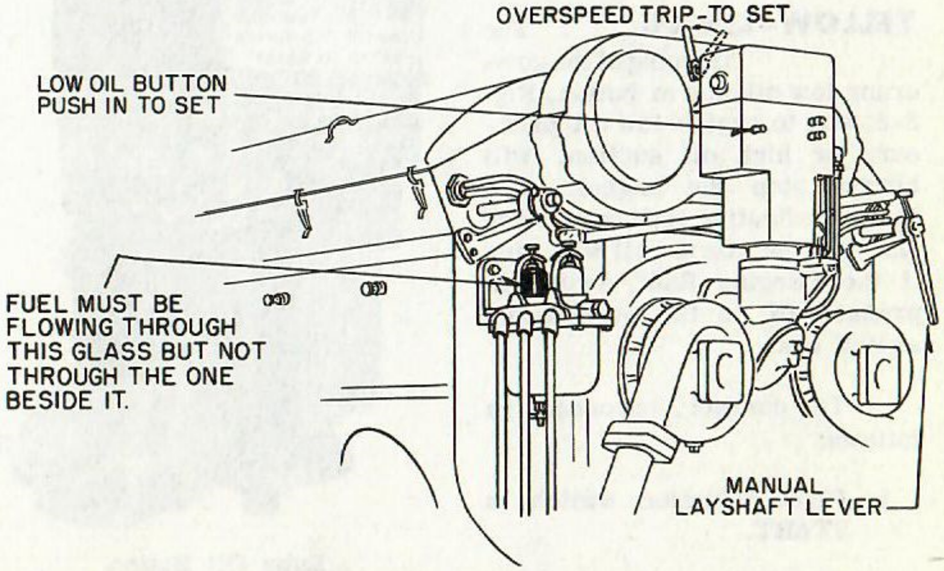
A "TRUE" AC failure is evident when the Blue light and bell are ON with the engine running and the isolation switch in RUN. To correct a "TRUE" AC


FILL
OFF
RUN
VAPOR
CONTRO
TCH

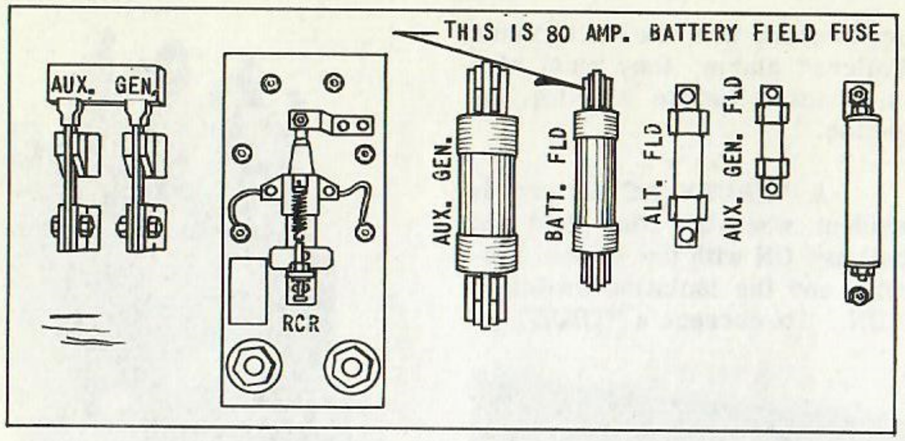
Boiler Switch
Fig. 3-4



NVR Relay
Fig. 3-5


OVERSPEED TRIP-TO SET
LOW OIL BUTTON PUSH IN TO SET
FUEL MUST BE FLOWING THROUGH THIS GLASS BUT NOT THROUGH THE ONE BESIDE IT.
MANUAL LAYSHAFT LEVER

Overspeed Trip And Fuel Flow Check
Fig. 3-6



Low Voltage Panel
Fig. 3-7

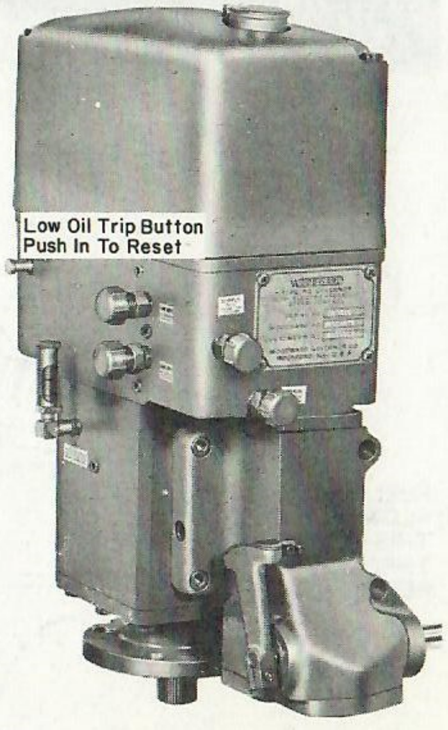
failure, shut engine down and check auxiliary generator field, alternator field and auxiliary generator (battery charging) fuses; all MUST be good. See Fig. 3-7.

NOTE: If "Engine Run" switch is OUT, or PC light is ON (PC switch open) the "Alternator Failure" alarm signals are inoperative.

**YELLOW—Low Oil** The tripping of the governor low oil alarm button, Fig. 3-8, due to engine low oil pressure or high oil suction, will always stop the engine. The yellow indicating light will flash ON, and the alarm bell will ring if the "Engine Run" switch is pressed IN on the push-button switch box.

To correct, proceed as follows:

1. Place isolation switch in START.
2. Reset low oil trip button.
3. Check engine lubricating oil level on engine oil pan dipstick, Fig. 3-9.
4. Check for broken or cracked oil lines.



Lube Oil Button
Fig. 3-8

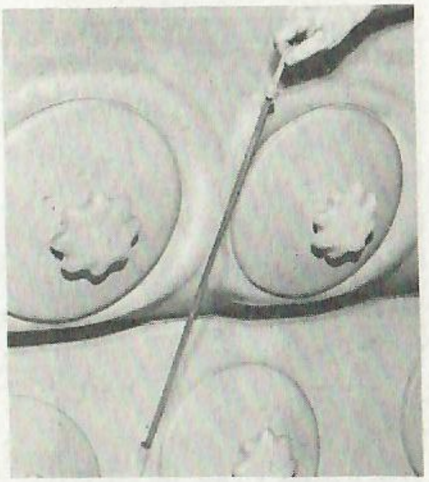
5. Restart engine.
6. Check oil pressure (must be a minimum of 6 p.s.i. at IDLE).

NOTE: Do not repeatedly start engine if the LOW OIL button keeps shutting the engine down.

## ADDITIONAL SAFETY DEVICES

302 **Ground Relay** When the ground relay, located on the engine room side of the electrical cabinet, trips open (white indicator pointing to red dot), see Fig. 3-10, the engine speed and load will automatically be reduced to IDLE, or to STOP if the throttle is in Run 5 or 6.

To correct: Isolate engine, reset ground relay, start engine if necessary and place engine "on the line." If the ground relay continues to trip, reset, and leave engine isolated.



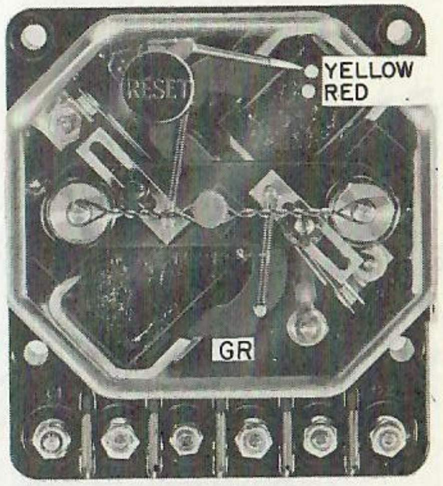
Engine Oil Pan Dipstick
Fig. 3-9

UNDER NO CONDITION OF REPEATED WHEEL SLIP ACTION OR GROUND RELAY ACTION SHOULD A UNIT BE ISOLATED AND ALLOWED TO REMAIN IN CONSIST UNLESS IT IS CERTAIN THAT ALL OF THE WHEELS ARE ROTATING FREELY.

303 **"PC" Switch Open** The "PC" switch is an air operated electric switch that is tripped open by any "penalty" or "emergency" air brake application. When tripped, the White "PC light" at the engineman's control station will flash on but the alarm bell will not ring. The engine speed and load are automatically reduced equivalent to throttle position No. 1. If the "PC" switch tripped open with the throttle in Run 5 or 6, the engine would stop.

To automatically reset the "PC" switch:

1. Close throttle to IDLE.



Ground Relay
Fig. 3-10

2. Place automatic brake valve in LAP.

3. Place foot on safety control foot pedal (if used).

4. Wait until application pipe builds up to normal pressure; listen for exhaust or watch "PC" switch light. If, after an emergency application, the "PC" switch does not reset itself with the automatic brake in LAP, move the brake valve to RUNNING. The "PC" switch is set when the light goes out.

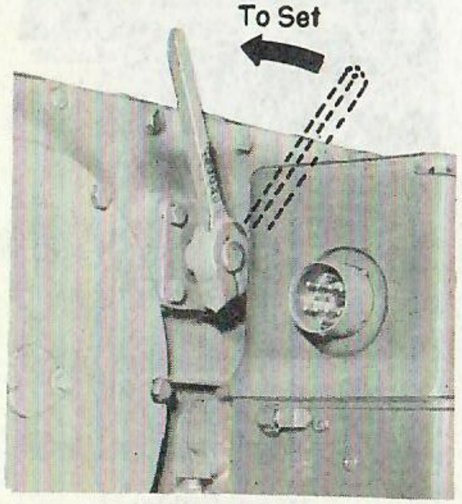
5. Reset train control (if used).

6. Place automatic brake valve in RUNNING.

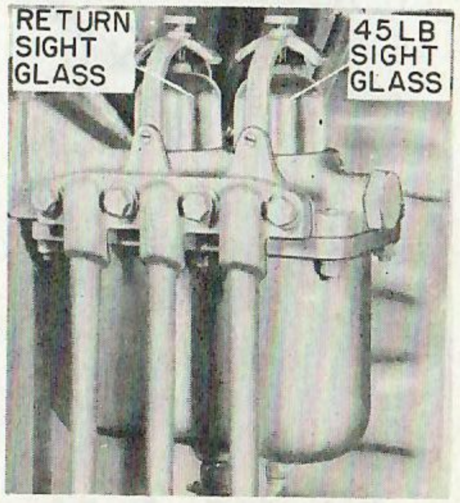
304 **Engine Overspeed Trip** If the engine speed should exceed approximately 910 RPM an overspeed device, Fig. 3-11, located on the front end of the engine will trip and stop the engine by preventing the injectors from injecting fuel into the cylinders. The alarm bell and Blue light will come on if the engine is stopped in this manner while "on the line." The overspeed trip must be latched in the SET position before the engine can be restarted.

305 **Fuel Flow** For proper operation, a good flow of fuel (clear and free of air bubbles) should be indicated by the fuel return sight glass, Fig. 3-12, located on the sintered bronze filter assembly.

If fuel is not flowing through return sight glass, check fuel pump motor. If motor is stopped. check, (1) in "lead" unit, the "Control and Fuel Pump" switch on the engineman's Push-Button switch box MUST be IN, and the 30-ampere control fuse must be good, (2) "Fuel Pump" switch on engine control panel must be "ON", (3) 10-ampere fuel pump motor fuse and 80-ampere control fuse must be good in "troubled" unit, (4) control knife switch and main battery switch must be closed and, (5) for loose cable connections to motor. If pump is running but fuel is not pumped, check, (1) fuel supply, (2) position of emergency fuel cutoff valve, (3) a suction leak in piping, (4) clogged suction filter, (5) a slipping coupling at fuel pump.



Overspeed Trip
Fig. 3-11

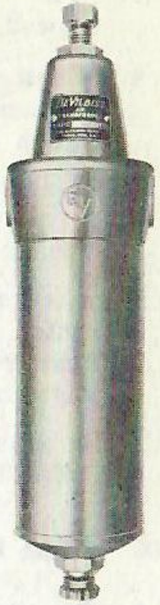


Fuel Sight Glasses
Fig. 3-12

306 **Emergency Fuel Cut-off Valve** Pulling any one of the three emergency fuel cutoff valve pull rings will shut off the fuel supply to the fuel pump (one is located in the operating cab of each "A" unit or on the engineroom wall at the governor end of the engine in each "B" unit, and one on each side of the locomotive near the fuel tank filler cap).

The cutoff valve is located on the underside of the fuel tank on the left side of the locomotive. Action of the valve is as shown in Fig. 3-13. To reset, push in on the valve yoke "push rod" extension which can be reached from the left side of the unit. Pushing in on this rod as far forward as possible will reopen the valve.

307 **Control Air Pressure** For satisfactory operation of the pneumatically operated contactors and switches used in the control circuit, the electrical control air pressure gauge in the electrical cabinet adjacent to distribution panel must indicate 90 ± 3 lbs. The pressure regulator, Fig. 3-14, is located behind the steps leading into the operating cab on the right (engineman's) side of of the locomotive. To raise or lower the pressure, change the adjustment on top of regulator. A drain cock is provided on the bottom of the regulator for draining the moisture.

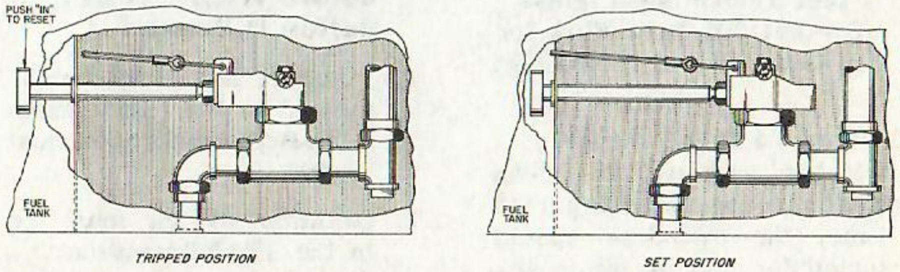


Control Air Regulator
Fig. 3-14

## CORRECTION OF DIFFICULTIES

308 If The Engine Goes To Idle

1. Ground relay might be tripped.
2. No voltage relay (NVR) might be open (Blue light will be ON).



Emergency Fuel Cut-Off Valve
Fig. 3-13

3. "PC" switch might be tripped.
4. "Engine Run" switch on the engineman's Push-Button switch box might be OUT.
5. 15-ampere fuelpump fuse, in the "lead" unit may be burned out.
6. "Control and Fuel Pump" switch on the engineman's Push-Button switch box might be OUT.
7. Isolation switch might be in "START."

### 309 If The Engine Stops

1. Throttle might be in STOP position.
2. Low oil pressure button on the governor might be OUT.
3. Engine overspeed device might have tripped.
4. No voltage relay (NVR) might have opened with throttle in RUN 5 or 6.
5. Ground relay might have tripped with the throttle in RUN 5 or 6.
6. "PC" switch might have tripped with the throttle in Run 5 or 6.
7. No fuel flowing through "fuel return sight glass." See Art. 305, Fuel Flow, for possible causes of trouble.

### 310 How To Start Engine

If the engine has been stopped for a considerable period of time, the cylinders should be tested for fuel or water accumulation before starting engine, (see Art. 317).

1. Place throttle in Idle and reverse lever in Neutral.
2. Place isolation switch in the START position.
3. In the electrical cabinet, on the distribution and low voltage panels, see that all fuses are securely in place and that all knife switches are closed.
4. At the engineman's Push-Button switch box "push in" the "Control and Fuel Pump" and "Engine Run" switches.
5. Place "Fuel Pump" switch on engine control panel in "ON" position.
6. After allowing a few seconds for fuel to flow through return sight glass, Fig. 3-12, solidly press the "START" button and hold until the engine starts. If the engine fails to start after 15 seconds of rotation, check possible troubles listed under Art. 311-312 before again trying to start engine.
7. After allowing time for the lube oil pressure to build up, place isolation switch in the RUN position.
8. Check ground relay.

### 311 If The Engine Does Not Rotate When "Start" Button is Pressed

1. "Control and Fuel Pump" switch on the engineman's Push-Button switch box must be IN.
2. Isolation switch must be in the START position.
3. 400-ampere starting fuse, 30-ampere control fuse and 80-ampere control fuse must be good.
4. Main battery switch and the Control knife switch in the electrical cabinet must be closed.

### 312 If The Engine Rotates But Does Not Start When "Start" Button is Pressed

1. Low oil pressure button on the governor must be pressed IN.
2. Engine Overspeed trip must be "Set."
3. No fuel flowing through "Fuel return sight glass." See Art. 305, Fuel Flow, for possible causes of trouble.

### 313 If The Engine Does Not Speed Up When Throttle is Opened

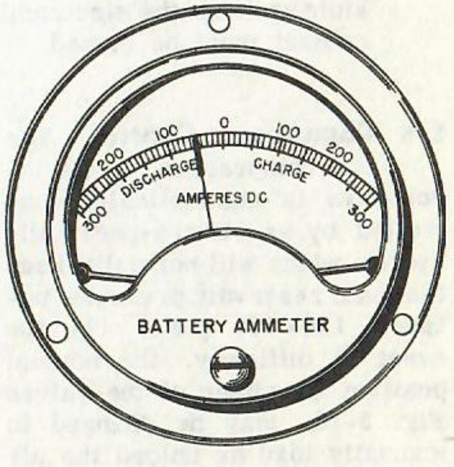
1. "Control and Fuel Pump" and "Engine Run" switches on engineman's Push-Button switch box must be IN.
2. Isolation switch must be in RUN position.
3. PC switch must not be tripped.
4. Ground relay must not be tripped.
5. No Voltage Relay (NVR) must not be open.
6. 15-ampere fuel pump fuse must be good.
7. No fuel flowing through "Fuel return sight glass." See Art. 305, Fuel Flow, for possible causes of trouble.

### 314 Engine Speeds Up But Locomotive Does Not Move When Throttle is Opened

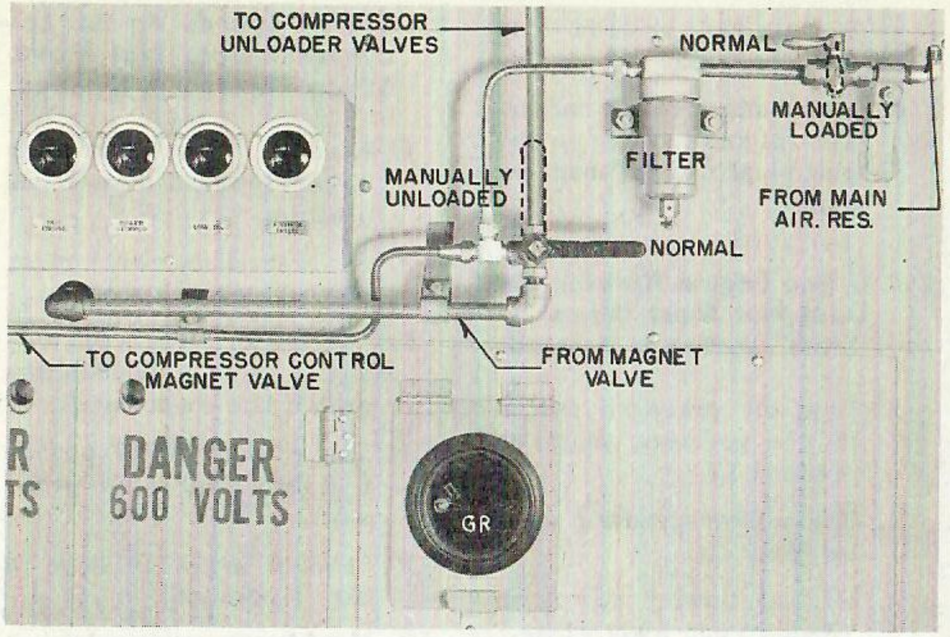
1. Reverse lever must be in either forward or reverse position.
2. Reverser drum switch must not be locked in neutral.
3. "Generator Field" switch on engineman's "Push-Button switch box must be IN.
4. There must be 90 pounds (± 3 lbs.) control air pressure.
5. Selector lever must be in No. 1 position.
6. Hand brakes and air brakes must be released.
7. 80-ampere battery field fuse must be good.

### 315 Battery Ammeter Shows Continual Discharge, Fig. 3-15.

1. Battery charging contactor located in the electrical cabinet must be closed.



Battery Ammeter
Fig. 3-15


TO COMPRESSOR UNLOADER VALVES
NORMAL
MANUALLY LOADED
FILTER
MANUALLY UNLOADED
FROM MAIN AIR. RES.
NORMAL
TO COMPRESSOR CONTROL MAGNET VALVE
FROM MAGNET VALVE
DANGER 600 VOLTS
GR

Manual Unloader Valve
Fig. 3-16

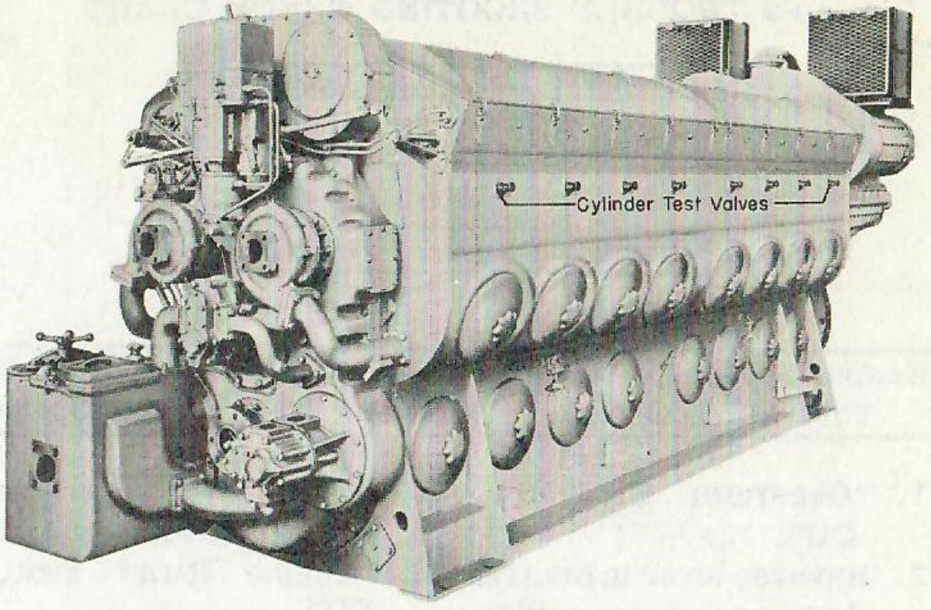
2. 150 or 250-ampere auxiliary generator (battery charging) fuse must be good.
3. The "Auxiliary Generator Field" fuse in the electrical cabinet must be good.
4. The auxiliary generator knife switch in the electrical cabinet must be closed.

316 **Compressor Control** The air compressor on the locomotive is automatically controlled by an electro-pneumatic system which will normally keep the main reservoir pressure between 130 - 140 p.s.i. In the event of difficulty, the normal position of either of the valves Fig. 3-16, may be changed to manually load or unload the air compressor in the troubled unit.

317 **Cylinder Test Valves** Each cylinder is equipped with a test valve, Fig. 3-17, for the purpose of testing for fuel or water accumulation in the cylinders prior to starting an engine that has been shut down for a considerable period of time.

To make this test, remove the 400-ampere starting fuse, open all cylinder test valves approximately 3 full turns, and use the engine jacking tool to rotate the engine one complete revolution. If liquid is discharged from any cylinder, investigate; if not, close cylinder test valves, replace 400 ampere starting fuse, and start engine in the usual manner.

If the engine is running and any cylinder test valve is heard to be leaking, the engine should be stopped, and the valve(s) should be tightened.


Cylinder Test Valves

Cylinder Test Valves
Fig. 3-17

## F9 TROUBLE SHOOTING CHECK CHART

### LOCOMOTIVE LOSES POWER (OR DOES NOT MOVE)

### DIESEL ENGINE RUNNING

#### Engine Speeds Up When Throttle Is Opened

1. "Generator Fld." Sw. OUT
2. Reverse lever in Neutral
3. Reverser drum switch (in electrical cabinet) locked in Neutral
4. Selector lever in OFF position
5. Control air pressure low
6. 80 amp. batt. fld. fuse burned out
7. Brakes set

#### Engine Does Not Speed Up When Throttle Is Opened

1. Ground relay tripped
2. Isolation switch in Start
3. "Engine Run" switch OUT
4. "Control and Fuel Pump" switch OUT
5. "PCS" light ON
6. "NVR" light ON
   - a. Auxiliary generator field fuse blown
   - b. Alternator field fuse blown
   - c. Auxiliary generator output fuse burned out
7. Control knife switch out
8. Loose governor cable

### ADDITIONAL SAFETY DEVICES NOT AFFECTING LOCOMOTIVE LOSS OF POWER

#### Hot Engine Alarm

1. Cooling water level low
2. AC cooling fan contactors opened
3. Shutters not opened

#### Steam Boiler Stopped Alarm

1. Motor overload tripped
2. Stack switch tripped
3. Coil blowdown valve open
4. See Section 6

## F9 TROUBLE SHOOTING CHECK CHART

### LOCOMOTIVE LOSES POWER (OR DOES NOT MOVE)

### DIESEL ENGINE STOPPED

#### Causes Which Stop Engine Only In Throttle 5 and 6

1. Ground relay tripped
2. "NVR" de-energized
3. "PCS" actuated
4. "Engine Run" switch OUT

#### Causes Which Stop Engine All Throttle Positions

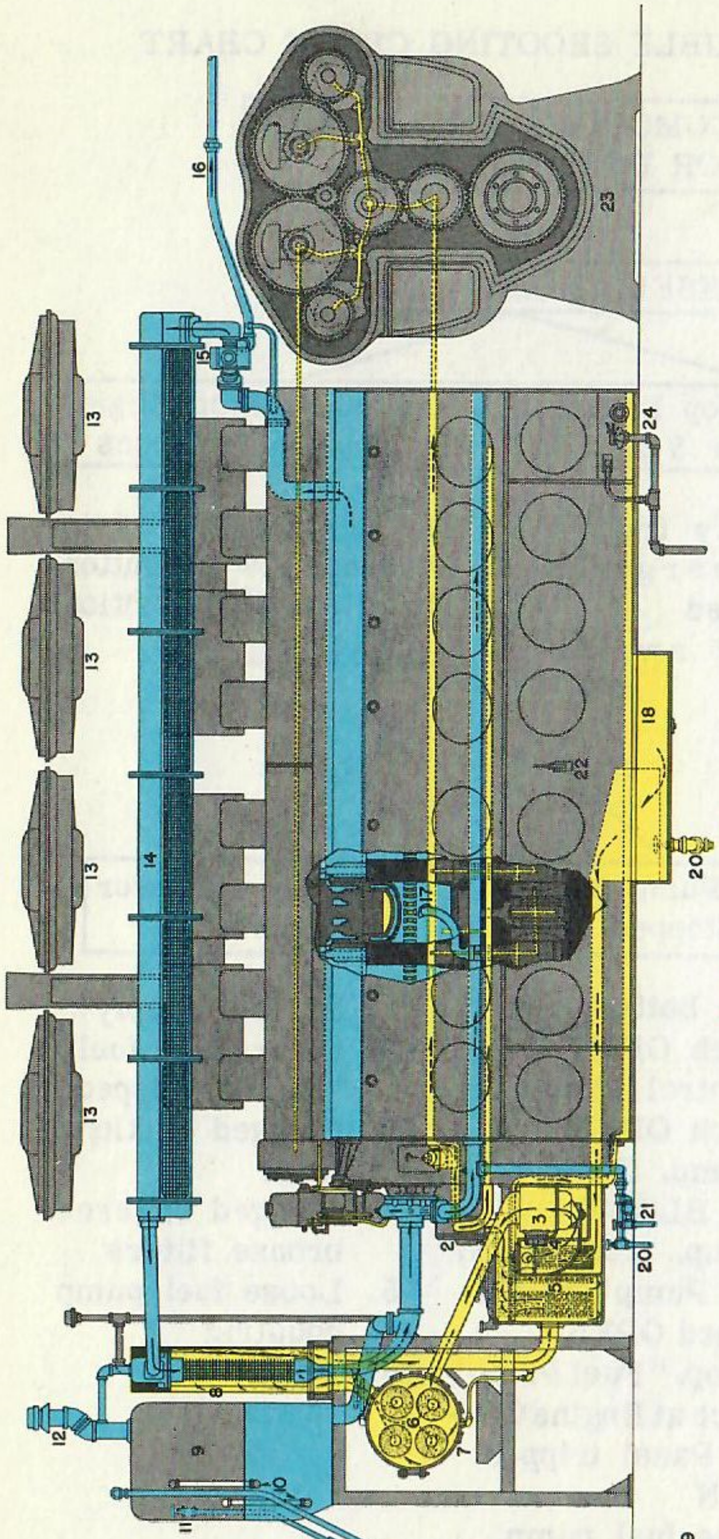
1. Engine overspeed trip
2. Governor low oil button
3. Throttle in Stop position
4. Lack of fuel

##### Fuel Pump Motor Stopped

1. Main battery switch OPEN
2. " Control " knife switch OPEN
3. 60 amp. Control fuse BLOWN
4. 30 amp. "Control and Fuel Pump" switch tripped OPEN
5. 15 amp. "Fuel Pump" switch at Engine Control Panel tripped OPEN
6. Loose fuel pump cable

##### Fuel Pump Motor Running

1. No fuel supply
2. Emergency fuel "cutoff" tripped
3. Clogged suction filter
4. Clogged sintered bronze filters
5. Loose fuel pump coupling
6. Broken fuel suction line



🟦 Water
🟨 Lubricating Oil

1. Water Pump
2. Lubricating Oil Pump
3. Scavenging Oil Pump
4. Sump Oil Strainer
5. Lube Oil Strainers
6. Lube Oil Filter
7. Lube Oil Relief Valves
8. Lube Oil Cooler
9. Cooling Water Tank
10. Water Level Gauges
11. "G" Valve
12. Roof Filler
13. Cooling Fans
14. Radiator
15. Thermostat Switch
16. To Cab Heater
17. Cylinder Liner
18. Engine Sump
19. Side Filler
20. Drains
21. Steam Admission Line
22. Bayonet Gauge
23. Camshaft Drive Gear Train
24. Air Box Drain

Fig. 4-1 - Schematic Of Cooling And Lube Oil Systems

# SECTION 4

## COOLING, LUBRICATING OIL, FUEL OIL AND AIR SYSTEMS

## COOLING SYSTEM

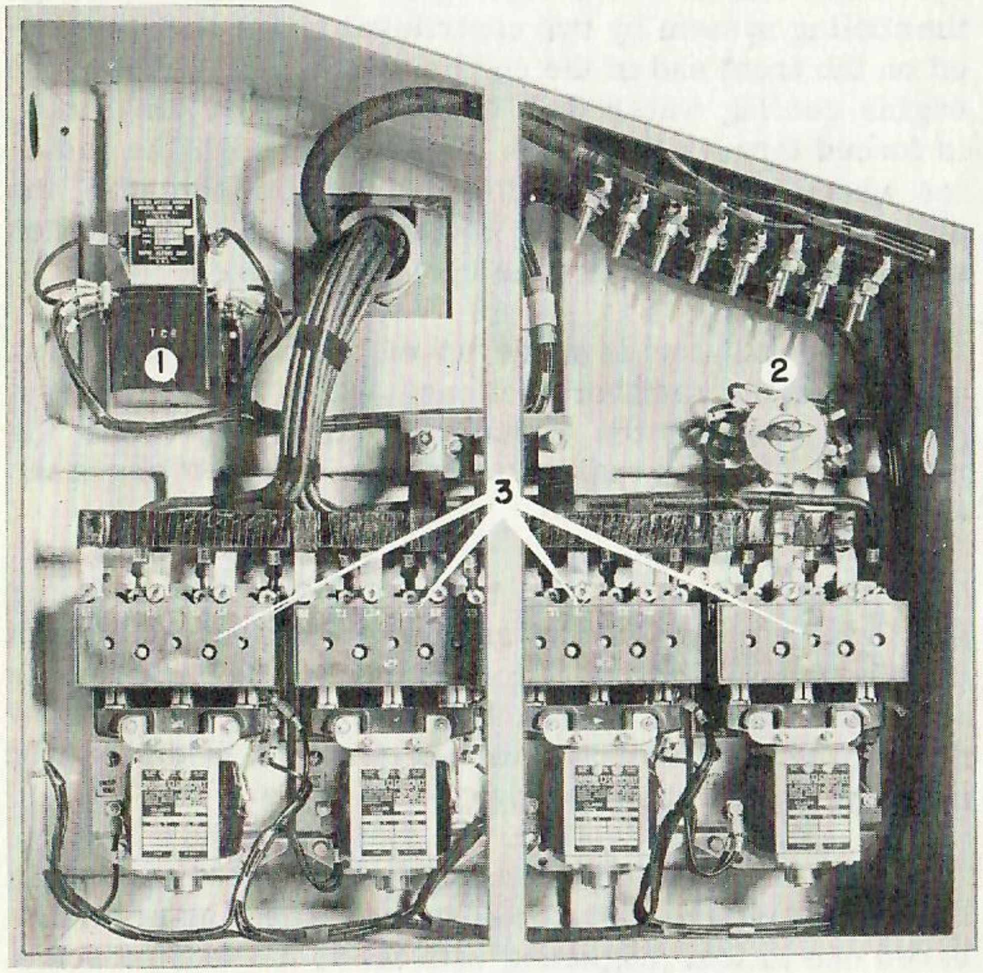
A schematic flow diagram of the engine cooling system is shown in Fig. 4-1. Water is circulated through the cooling system by two centrifugal type pumps mounted on the front end of the engine. Water, drawn from the engine cooling water tank and oil cooler by the pumps, is forced through the engine and then through the radiator where it is cooled. After leaving the radiator, the water flows through the oil cooler and then to the suction side of the pumps where the cycle is repeated.

The radiator is made up of two banks; each bank consists of six radiator sections. Water leaving the engine and entering the radiator is divided between the right and left bank radiator sections, mounted above the engine.

Flow of cooling air through the finned radiator sections is controlled by shutters and four AC driven cooling fans. The operation of the fans and shutters is entirely automatic. When the fans are operating, air flows up through the radiator sections and is discharged from the roof of the carbody.

The four AC driven cooling fans are mounted in the roof above the radiator sections. The fans are numbered one to four, beginning with the #1 fan located nearest the cab end or front end of the locomotive.

A thermostat switch, actuated by engine water temperature, controls the operation of the shutters and cooling fans through the temperature control relay, shutter air magnet valve, and the AC cooling fan contactors, Fig. 4-2. A "Summer-Winter" selector switch located in the AC contactor panel, provides a method of altering the sequence of the fan and shutter operation. With the switch in the "Summer" position, the shutters will open before the first fan (#1) is energized. In the "Winter" position the shutters will open when the third fan (#3) is energized. As the outlet engine cooling water temperature rises, the sequence of fan and shutter operation is as follows:



1. Temperature Control Relay 2. Summer-Winter Switch (SWS)
3. AC Cooling Fan Contactors

AC Contactor Panel
Fig. 4-2

With the "Summer-Winter" switch in "Summer" position:

163° F - Holding circuit for TCR is established
166° F - Temperature Control Relay (TCR) energized-shutters also open
169° F - #1 AC cooling fan starts
172° F - #2 AC cooling fan starts
175° F - #3 AC cooling fan starts
178° F - #4 AC cooling fan starts

With the "Summer-Winter" switch in "Winter" position:

163° F - Holding circuit for TCR is established
166° F - Temperature Control Relay (TCR) energized
169° F - #4 AC cooling fan starts
172° F - #2 AC cooling fan starts
175° F - #3 AC cooling fan starts
Shutters also open
178° F - #1 AC cooling fan starts

As the engine cooling water temperature falls, any cooling fans that started will continue to run and the shutters, if open, will stay open until the outlet cooling water temperature drops to below 163° F. At this temperature the AC contactors will drop out (fans stop) and the shutters will close.

In the event of excessive cooling water temperature, the high temperature alarm switch will close, causing a red light (Hot Engine) to flash on in the unit affected, and the alarm bells to ring in all units.

400 **Operating Water Level** Operating water levels are stencilled on the water tank next to the water level sight gauge glasses to indicate minimum and maximum water levels with engine running and stopped. The

engine should never be operated with the water below the low water level, Fig. 4-3. Progressive lowering of the water in the gauge glass indicates a water leak in the cooling system and should be reported.

401 **Filling Cooling System** The system is filled either through the filler pipe located on the roof of the locomotive above the water tank, or through the filler pipe at the rear of the unit on either side. To fill the system proceed as follows (steps 5 to 8 are necessary only when filling a dry or nearly dry engine):

1. Stop engine.
2. Open "G" valve.
3. Fill slowly until water runs out the "G" valve drain pipe.
4. Close "G" valve.
5. Start engine and run several minutes. This will eliminate any air pockets in the system.
6. Shut down engine and open "G" valve and wait 3 minutes.
7. Add water until it runs out "G" valve drain pipe.
8. Close "G" valve.

If the cooling system of a hot engine has been drained, do not refill immediately with cold water. If this is done, the sudden change in temperature might crack or warp the cylinder liners and heads.

CAUTION: 1. Do not attempt to fill the cooling system through the drain pipe located underneath the locomotive.

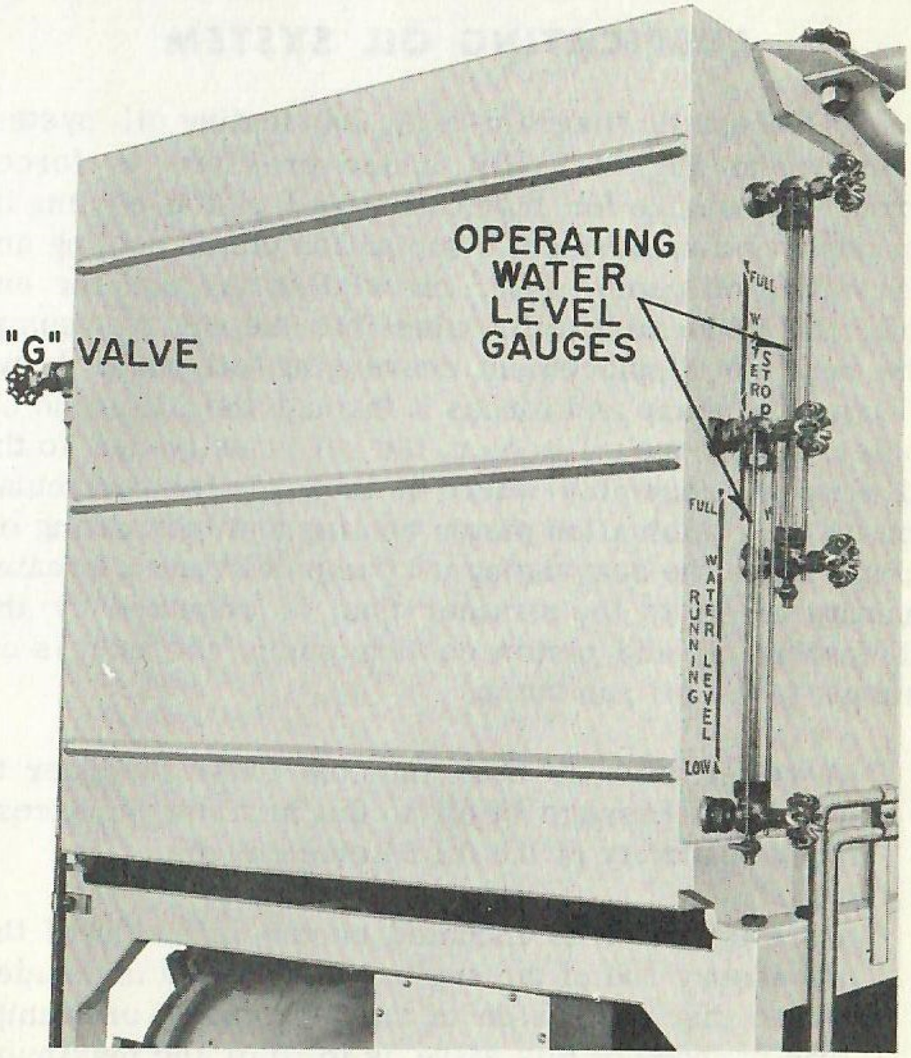
2. The system should not be filled above the maximum water level indicated on the water tank, Fig. 4-3.

   a. To prevent freezing of radiators in winter, when engine is shut down.

   b. To prevent loss of rust inhibitor when draining back to "G" valve level.

402 **Draining Cooling System** The entire cooling system can be drained through the drain valve on the floor in front of the engine, with the exception of the water pump on the right hand side of the engine. To drain the right hand water pump, open the drain on the bottom of the water pump housing.

403 **Cab Heating** A cab heater is located on each side of the cab. Hot water from the engine cooling water system passes through the heaters, and motor



Cooling Water Tank
Fig. 4-3

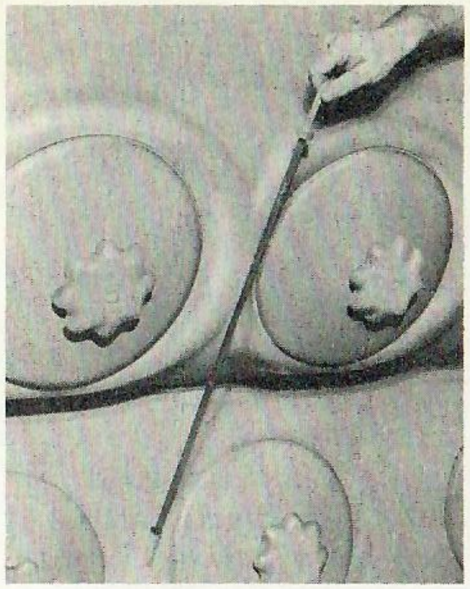
driven fans provide air circulation. The flow of water to both heaters is controlled by a valve in the supply line, located over the left-hand engine room steps. This valve must be kept wide open at all times in freezing weather. The output of each heater can be varied by use of the cab heater switches. The switches have four positions "OFF", 1, 2, 3, which provide three different motor speeds. If engine in the lead unit is shut down in freezing weather, steam may be admitted to the cab heaters.

## LUBRICATING OIL SYSTEM

A schematic diagram of the lubricating oil system is shown in Fig. 4-1. Oil under pressure is forced through the engine for lubrication and piston cooling by the positive displacement combination piston cooling and lubricating oil pump. After circulating through the engine, the lubricating oil drains into the oil pan sump. The positive displacement scavenging oil pump draws oil from the sump and forces it through the filter and oil cooler. From the oil cooler, the oil is delivered to the oil strainer assembly where it is ready for recirculation by the combination piston cooling and lubricating oil pump. Since the scavenging oil pump delivers a greater quantity of oil to the strainer than is required by the lubricating oil and piston cooling pump, the excess oil returns to the oil pan sump.

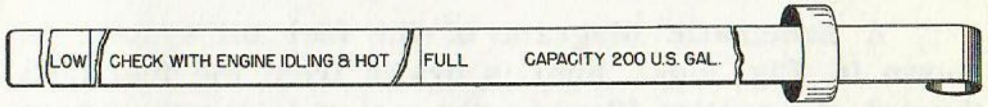
A relief valve is built into the filter in order to allow the passage of oil to the strainer in excess of the capacity of the oil filter elements.

A relief valve is mounted on the left side of the accessory end of the engine. This valve is located in the discharge side of the lubricating oil pump. The purpose of this valve is to limit the maximum pressure of the lube oil entering the engine lube oil system to approximately 60 pounds.



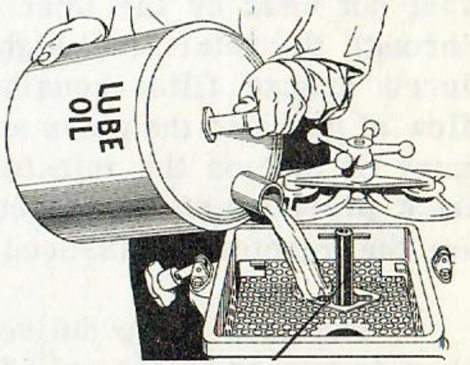
Lube Oil Level
Fig. 4-4

404 **Oil Level** The oil level should be checked, Fig. 4-4, with the engine hot and running at idle speed. The dipstick should show a level between "Low" and "Full," Fig. 4-5, on either bayonet gauge (one on each side of engine). When the engine is stopped, the oil in the filter and cooler will drain back into the oil pan. If the oil level is checked with the engine stopped, the reading on the "dipstick" will be above the "Full" mark.



Oil Dipstick
Fig. 4-5

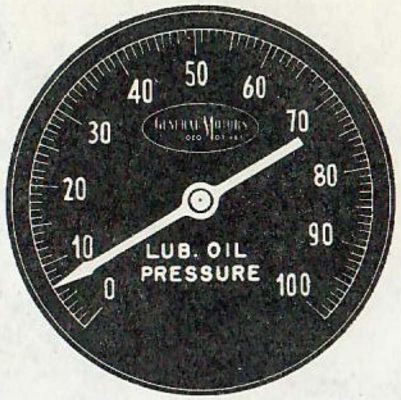
405 **Adding Oil to System** Oil may be added with the engine running or stopped. When oil is added to the system, it must be poured through the opening having the square cap on top of the strainer housing, Fig. 4-6. Should the round caps be removed while the engine is running, hot oil under pressure will come from the openings and possibly cause personal injury.



STRAINER DRAIN VALVE
Open ONLY If Draining
The Engine Oil Pan

Adding Oil To Engine
Fig. 4-6

406 **Oil Pressure** A lubricating oil pressure gauge is mounted on the engine control panel, Fig. 4-7. Oil pressure at 835 RPM is normally 40 to 50 pounds. It should not drop below 20 pounds. At idle the pressure should be at least 6 pounds. In the event of dangerously low oil pressure the engines will automatically be stopped by action of the governor low oil pressure button.



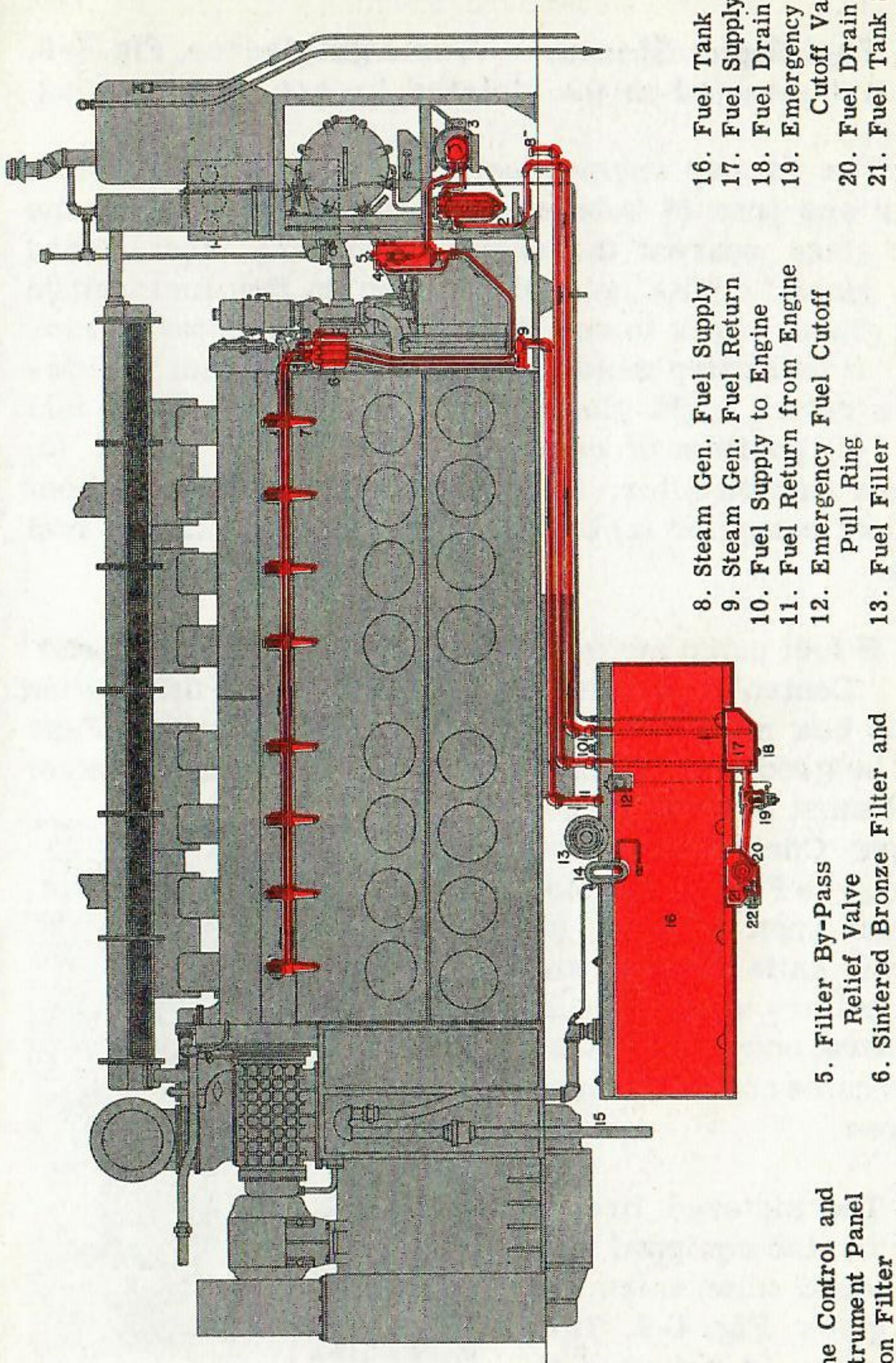
Lubricating Oil
Pressure Gauge
Fig. 4-7

## FUEL OIL SYSTEM

A schematic diagram of the fuel oil system is shown in Fig. 4-8. Fuel is drawn from the fuel tank through the suction filter by the motor driven gear type pump. From the pump the fuel is forced consecutively through the Ful-Flo filter and the sintered bronze filter. After passing through the double element sintered bronze filter, the fuel flows to the injectors. The excess fuel not used by the injectors returns to the fuel tank through the return fuel sight glass, mounted on the sintered bronze filter housing. An orifice restricts the flow of fuel into the glass and causes a slight back pressure of fuel on the injectors. By maintaining a slight back pressure on the injectors a positive supply of fuel for the injectors is assured.

The fuel pump delivers more fuel to the engine than is burned in the cylinders. The excess fuel circulated through the injectors is used for cooling and lubricating the fine working parts of the injectors.

A 15-pound relief valve is connected across the inlet and outlet fuel lines of the Ful-Flo filter. This re-



1. Engine Control and Instrument Panel
2. Suction Filter
3. Fuel Pump and Motor
4. Fulflo Filter
5. Filter By-Pass Relief Valve
6. Sintered Bronze Filter and Sight Glass Assembly
7. Injector
8. Steam Gen. Fuel Supply
9. Steam Gen. Fuel Return
10. Fuel Supply to Engine
11. Fuel Return from Engine
12. Emergency Fuel Cutoff Pull Ring
13. Fuel Filler
14. Sight Gauge
15. Vent and Flame Arrestor
16. Fuel Tank
17. Fuel Supply Sump
18. Fuel Drain Plug
19. Emergency Fuel Cutoff Valve
20. Fuel Drain Plug
21. Fuel Tank Sump
22. Fuel Tank Water Drain Plug

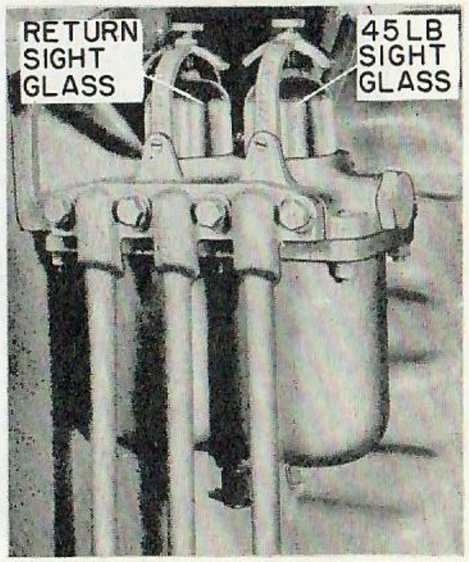
Schematic Of Fuel Oil System
Fig. 4-8

lief valve by-passes fuel to the sintered bronze filter if the Ful-Flo filter elements become clogged.

407 **Fuel Sight Glasses** Two sight glasses, Fig. 4-9, are mounted on the sintered bronze filter housing.

For proper engine operation, a good flow of fuel (clear and free of bubbles) should be indicated in the sight glass nearest the engine called the "fuel return sight glass." With no fuel showing in the fuel return sight glass, check to see if the fuel pump motor is running. If fuel pump motor is running, and no fuel is flowing in return sight glass, check (a) fuel supply in fuel tank, (b) position of emergency fuel cut-off valve, (c) clogged suction filter, (d) suction leak in piping between tank and pump, or (e) broken or slipping coupling at fuel pump.

If fuel pump motor is stopped, check (a) in "Lead" unit "Control and Fuel Pump" switch on Push-Button switch box must be IN, and 30 ampere Control Fuse must be good, (b) "Fuel Pump" switch on Engine Control Panel must be ON, (c) 80-ampere Control fuse and 10-ampere Fuel Pump Motor fuse must be good, (d) control knife switch and main battery switch should be closed, and (e) fuel pump motor cable connection may be loose.



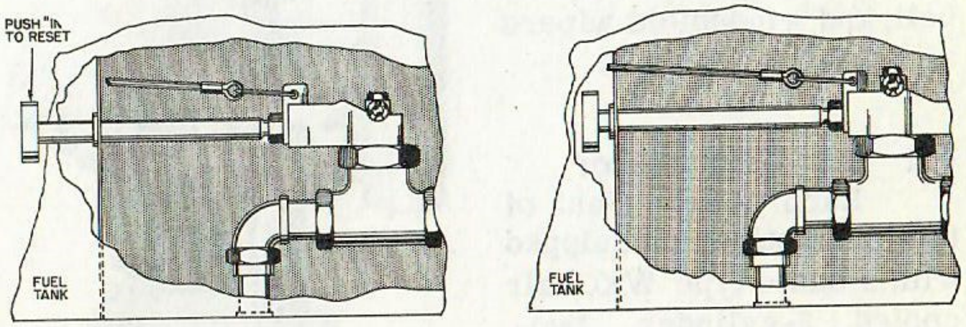
Sight Glasses
Fig. 4-9

The sintered bronze filter is also equipped with a 45-pound relief valve and sight glass, Fig. 4-9. This sight glass is referred to as the "45-pound sight glass" and is normally empty. When more than a trickle of fuel is seen in the 45-pound sight glass, it indicates that the relief valve is open. Fuel will pass through the 45-pound sight glass and relief valve to bypass the engine and return to the fuel tank in case the sintered bronze filter becomes clogged.

408 **Filling Fuel Tanks** The fuel tank can be filled from either side of the locomotive. Direct reading sight level gauges located on each side of the fuel tank adjoining the fuel fillers indicate level of fuel oil starting at 4-1/2" from the top of the tank and should be observed while filling the tank to prevent overflowing. The fuel should be filtered through a reliable fuel filter before it enters the tank. DO NOT HANDLE FUEL OIL NEAR AN OPEN FLAME.

409 **Fuel Gauge** The basic fuel tank capacity is 1200 gallons. Full length sight level gauges are located on each side of the front end of the fuel tank. A graduated plate shows the amount of fuel in the tank as indicated by the fuel level in the glass.

410 **Emergency Fuel Cutoff Valve** An "Emergency Fuel Cut-Off Valve," Fig. 4-10, is provided to cut



Tripped Position
Set Position

Emergency Fuel Cutoff Valve
Fig. 4-10

off the fuel supply to the fuel pump in the event of fire, or any emergency. It is located on the underside of the fuel tank on the left side of the locomotive. Adjacent to the fuel fill pipe on each side of the locomotive is a small box with a lift cover. Enclosed in this box is a pull ring attached to the end of the cable running to the fuel cut-off valve. A similar ring is located in the cab of the locomotive.

The fuel cut-off valve can be tripped by pulling any one of these three rings. If tripped, the valve must be reset manually.

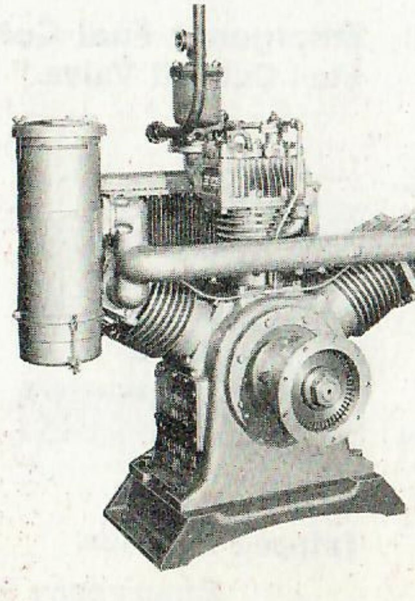
To reset the valve, "push in" on the rod extending from the valve compartment on the left side of the locomotive.

## AIR SYSTEM

Compressed air is not only used on a Diesel locomotive for operating the air brakes and sanders, but is also essential for proper operation of many other items. The reverser, power contactors, shutter operating cylinders, horn, bell, and windshield wipers are also air operated.

### 411 Air Compressor

Each power plant of the locomotive is equipped with a basic type WXO air cooled 3-cylinder, two-stage air compressor, Fig. 4-11. The compressor is driven through a flexible coupling from the armature shaft of the main generator.



Air Compressor
Fig. 4-11

The compressor has its own oil pump and pressure lubricating system. With the engine stopped the level in the compressor crankcase can be checked on the bayonet type gauge. At idle speed (275 RPM) and the compressor crankcase oil hot, the lubricating oil pressure should be approximately 15 to 20 pounds.

The compressor consists of two low pressure cylinders and one high pressure cylinder. The pistons of all three cylinders are driven by a common crankshaft. The two low pressure cylinders are set at an angle to the vertical high pressure cylinder. Air from the low pressure cylinder goes to an intercooler, or radiator, to be cooled before entering the high pressure cylinder. The intercooler is provided with a pressure gauge and relief valve. The gauge normally reads approximately 45 to 50 pounds when the compressor is loaded. The intercooler relief valve is set for 65 pounds. Any marked deviation of intercooler pressure from 45 to 50 pounds should be reported at the maintenance terminal.

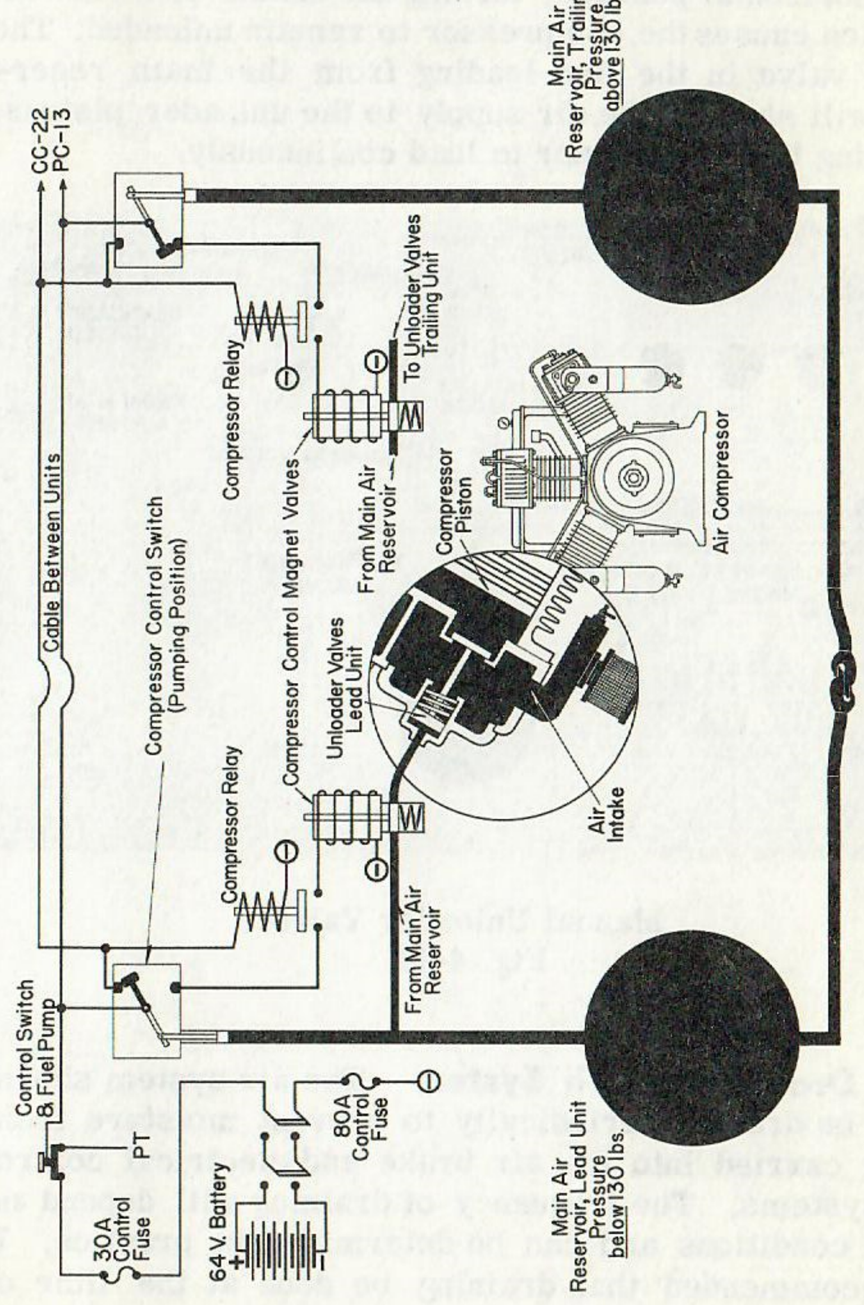
An oil separator, in the discharge air line from the high pressure cylinder, filters oil droplets and carbon particles out of the air. A drain valve is provided to drain the oil separator and should be drained once at each crew change and at the regular maintenance period. It is also recommended to drain the compressor intercooler (two drain valves are provided in the bottom header) and the main reservoirs when draining the compressor oil separator.

### 412 Compressor Control

Since the air compressor is directly connected to the engine and is in operation at all times when the engine is running, an unloader is provided in the heads of both high and low pressure cylinders which cuts out the compressing action when actuated by air pressure. The unloader accomplishes this by blocking open the suction, or intake, valves of the high and low pressure cylinders. When the air operating the unloader is cut off, the unloader releases the suction valves and the compressor resumes pumping. Air pressure from the main air reservoir actuates the unloader valves.

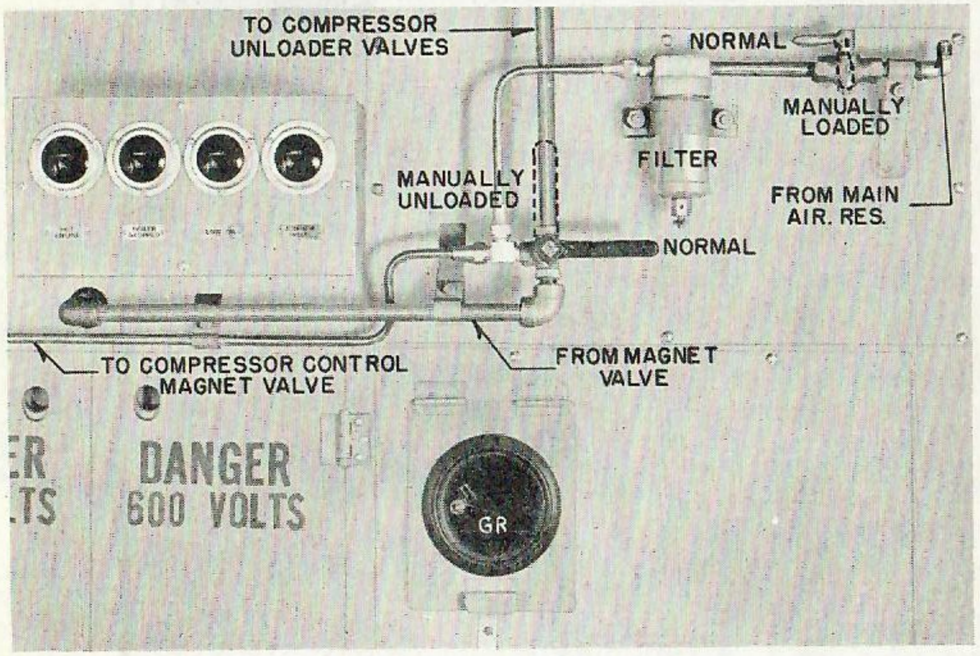
The loading and unloading of the compressor in each unit is controlled by an electro-pneumatic system, Fig. 4-12. The electrical arrangement is such that all compressors in the locomotive are synchronized to pump air into their respective main reservoirs when the main reservoir air pressure in any one unit drops to 130 pounds. When the air pressure in all main reservoirs reaches 140 pounds, the compressors will unload. Each unit is equipped with a compressor control switch (CCS) actuated by main reservoir pressure and a compressor relay (CR). A compressor control wire (CC) runs throughout the locomotive and connects the compressor relays in each unit in parallel.

The compressor control switch is located next to the alarm bell on the engine side of the electrical cabinet. This switch may be considered to be a single-pole double-throw switch that is thrown to the "loaded" position when the main reservoir pressure drops to 130 pounds, or to the "unloaded" position when the main reservoir pressure reaches 140 pounds. In the unloaded position the CCS causes the compressor control magnet valve to be energized, allowing air to pass through the valve to the compressor unloader pistons, stopping the compressing action. In the loaded position the CCS breaks the circuit to the compressor control magnet valve in that unit and causes current to flow through the CC wire energizing the CR relays in each unit. When the CR relay is energized its interlock breaks the circuit to the compressor control magnet valve regardless of the position of the CCS in that unit. Breaking the circuit to the compressor control magnet valve shuts off the supply of air to the compressor unloader pistons, and the compressor resumes pumping.


CC-22
PC-13
Main Air Reservoir, Trailing Unit Pressure above 130 lbs.
To Unloader Valves Trailing Unit
Compressor Relay
Compressor Piston
Air Compressor
Cable Between Units
Compressor Control Switch (Pumping Position)
Compressor Control Magnet Valves
From Main Air Reservoir
Unloader Valves Lead Unit
Air Intake
Compressor Relay
From Main Air Reservoir
Control Switch & Fuel Pump
PT
80A Control Fuse
30A Control Fuse
64 V. Battery
Main Air Reservoir, Lead Unit Pressure below 130 lbs.

Electro-Pneumatic Governor Control System
Fig. 4-12

413 **Manual Unloader Valve** A three-way valve is provided in case it is desired to keep an air compressor unloaded, Fig. 4-13, irrespective of the compressor control system. Normally the valve handle is in a horizontal position; turning the handle to a vertical position causes the compressor to remain unloaded. The other valve in the line leading from the main reservoir will shut off the air supply to the unloader pistons, allowing the compressor to load continuously.



Manual Unloader Valve
Fig. 4-13

414 **Draining of Air System** The air system should be drained periodically to prevent moisture from being carried into the air brake and electrical control air systems. The frequency of draining will depend on local conditions and can be determined by practice. It is recommended that draining be done at the time of each crew change, until a definite schedule can be determined by the individual railroad.

# SECTION 5

## ELECTRICAL EQUIPMENT

500 **Basic Electrical Systems** In full throttle, the rated horsepower of the engine is delivered to the direct coupled main generator. At the main generator the power of the engine is transformed into electrical power. The electrical power is then conducted to the four traction motors, two motors being located in each truck (each motor being geared to an axle).

The locomotive is designed so that within the current and voltage limits of the main generator, the power (KW) delivered to the traction motors at full throttle, is the same, regardless of the locomotive's speed.

The electrical system of the locomotive can be thought of as being divided into three separate systems:

1. High voltage system (includes dynamic braking system - if used).
2. Low voltage system.
3. Alternating current system.

The high voltage system is directly concerned with moving the locomotive; or in retarding the locomotive in case dynamic brakes are supplied and are in use. The main components of the high voltage system are the main generator, traction motors, forward and backward transition relays, shunt field contactor, motor shunting contactors, reverser drum, wheel slip relays, ground relay, series and parallel power contactors. On a locomotive equipped with dynamic brakes, the cam switch, braking contactors, and brake grids may also be considered to be in the high voltage system.

The low voltage system contains the control circuits which control the flow of power in the high voltage system, and those auxiliary circuits conducting power to the locomotive lights, heater fans, fuel pump and the main generator battery field. A 64 volt battery, in the low voltage system, is the source from which power is taken to start the Diesel engine. Once the engine is started, the auxiliary generator takes over the job of supplying power to the low voltage system.

The alternating current system includes an alternating current generator (called an alternator), four engine cooling fan motors, and four traction motor blower motors. The alternating current system provides a means of driving accessories, without the use of belt drives, at speeds which vary according to the speed of the engine.

501 **Main Generator** The main generator voltage is nominally 600 volts but this varies with engine speed and the conditions of operation of the locomotive. The main generator contains six field windings: starting, battery, shunt, differential, compensating, and commutating. The starting field is used only when the main generator is used as a starting motor to rotate the engine. With regard to locomotive operation, the shunt and battery fields are the more important; these two fields provide the main excitation of the generator.

The battery field is a low voltage, externally excited field. The current flowing through the battery field, which initially excites the main generator, is varied by the load regulator. By varying the strength of the battery field, the power output of the main generator is largely controlled. The battery field contactor opens or closes the circuit to the battery field.

The main generator is self-excited by the shunt field. The shunt field is a high voltage field whose excitation varies with the voltage of the main generator. A shunt field contactor opens or closes the circuit to the shunt field. Interlocks are built into the shunt field contactor so that this contactor must close before the battery field contactor can close.

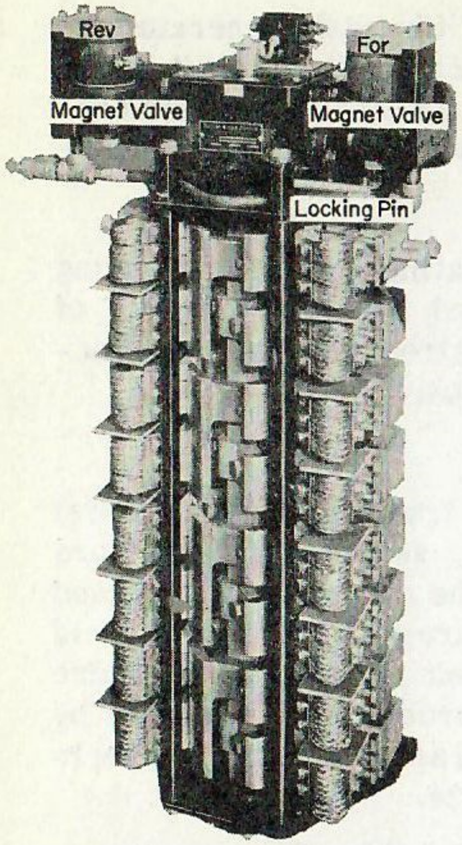
The differential, compensating and commutating fields are permanently connected and are a matter of engineering design providing desired generator characteristics and proper commutation.

502 **Traction Motors** The traction motors (Model D37) are direct current, series wound motors geared to the driving axles. The motors are reversed by changing the direction of current flow in the field windings, the direction of current flow in the armature always being the same. A reverser drum operated by electro-pneumatic control reverses the current flow in the traction motor field windings.

The traction motors are cooled by alternating current driven blowers, one for each motor. The traction motor blowers are mounted on the floor of the engine room and blow air through flexible ducts to the traction motors. The speed of the blowers varies with the speed of the engine; this is due to the engine speed varying the frequency of the alternator.

The maximum permissible top speed of the locomotive is limited by the safe RPM of the traction motor armature; thus a high speed gear ratio is required for high speed train operation. A low speed gear ratio is needed to start and use full horsepower with low speed tonnage trains without overheating and damaging the electrical equipment.

503 **Reversing Locomotive** Movement of the reverse lever to the forward or reverse position energizes the respective FOR or REV magnet valves on



Reverser Switch
Locked In Neutral
Fig. 5-1

the reverser, located in the electrical cabinet, Fig. 5-1. When either of the magnet valves is energized it allows control air to pass through the valve, moving the reverser to the desired direction (with four long segments showing on reverser drum, the reverser is in forward; eight short segments can be seen when in reverse position).

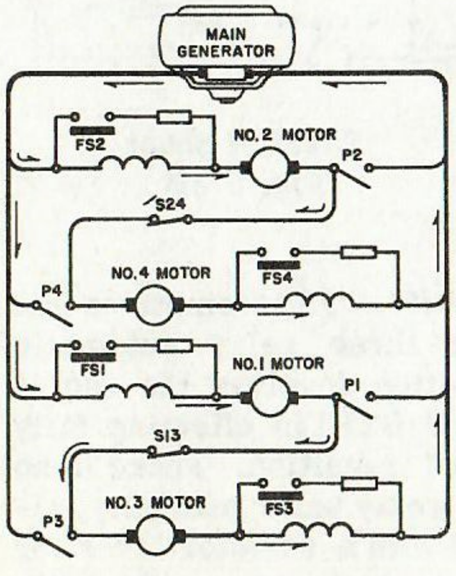
## 504 **Automatic Transition**

This term is applied to the changing of traction motor electrical connections on a Diesel-Electric locomotive so that full power may be obtained from the main generator within the range of its current and voltage limits. To look at it another way, transition is a method of adjusting the traction motor "back pressure" (counter-e.m.f.) bucking the input of power from the main generator so that this back pressure will not become too high at higher speeds nor too low at lower speeds.

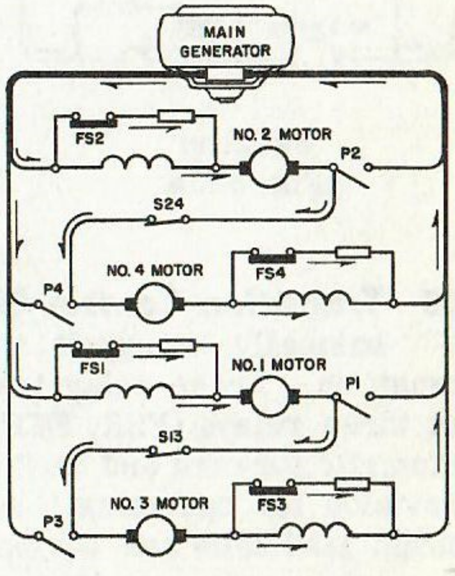
Standing still the traction motors have practically no "back pressure," or resistance to the input of current from the main generator. However, as the locomotive speed increases after starting in series-parallel (transition 1), Fig. 5-2A, the "back pressure" of the traction motors builds up and causes the main generator "pressure" (voltage) to increase so that it can continue forcing current into the motors. Although the main generator can vary its voltage over a wide range, there is a

practical operating limit to its ability to increase its voltage. If this practical voltage limit were exceeded the power output of the main generator and correspondingly, the engine, would drop off. To prevent this loss of power, a change is made in the electrical circuit just before the drop off begins The first change, Fig. 5-2B, from transition 1 to 2 (series-parallel-shunt) connects a by-pass (shunt) circuit around each of the traction motor fields. Shunting the traction motor fields effects a reduction in the "back pressure" of the traction motors, which in turn allows the voltage in the main generator to reduce itself (with a constant KW generator, as the voltage goes down the amperage goes up, and vice versa). Thus, by shifting to transition 2 more current can pass through the traction motor armatures to maintain the full power output of the locomotive.

As the locomotive speed increases there is again a tendency for the power to drop off. This time, when the main generator reaches sufficient voltage, a complete change in the electrical circuit is necessary to once again reduce the "back pressure" of the traction motors.

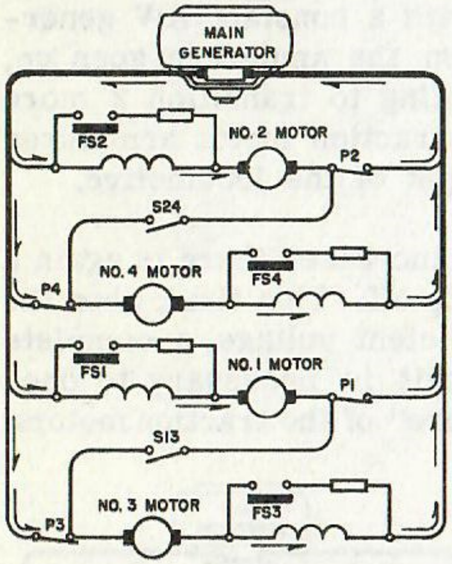


Series-Parallel
Fig. 5-2A

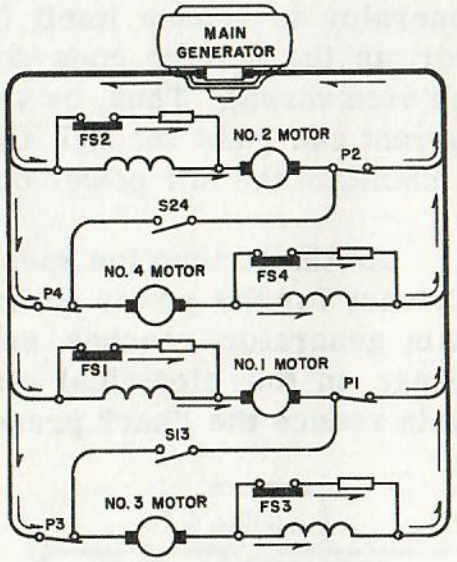


Series-Parallel Shunt
Fig. 5-2B

When this change, from transition 2 to 3 (parallel), Fig. 5-3A, is completed the main generator continues the full application of power until a still higher locomotive speed is reached. At this time, when the voltage increases, the motor shunting contactors are again closed (reducing the traction motor "back pressure") effecting transition from 3 to 4 (parallel-shunt), Fig. 5-3B. With decreasing speeds, as caused by grades, a reverse sequence of transition takes place to prevent exceeding the current limitations of the main generator.



Parallel
Fig. 5-3A



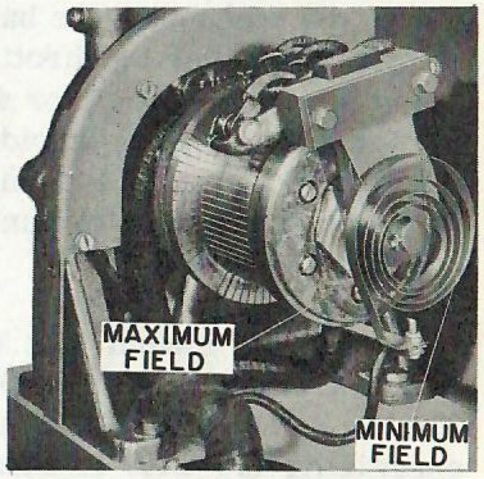
Parallel Shunt
Fig. 5-3B

505 **Transition Control Circuit** F9 locomotives are basically equipped with three relay automatic transition. Three relay transition involves the use of but three relays (FSR, FTR and BTR) in effecting fully automatic forward and backward transition. There is no provision for operating three relay units manually, although lead units are equipped with a selector lever for the purpose of controlling dynamic braking and/or use in multiple operation with older units not equipped for automatic transition.

The FSR and FTR are voltage operated relays, whereas, the BTR is a current operated device. Forward transition is always made at a predetermined main generator voltage. Backward transition is made at a predetermined main generator voltage from the shunting positions (4 to 3 and 2 to 1), by the dropping out of the FSR. Backward transition from the parallel position is made at a predetermined amperage by the picking up of the BTR.

506 **Load Regulator** The load regulator, Fig. 5-4, is an automatically operated rheostat connected in series with the battery field of the main generator. Engine oil pressure is used to force the rheostat to vary its position as directed by a pilot valve in the engine governor, loading the engine according to the throttle setting in the cab.

The load regulator has two components: (1) the pilot valve in the engine governor, and (2) a self-contained unit consisting of a hydraulic vane type motor attached to the commutator type rheostat. The only external wiring connections are two leads to the generator battery field circuit.



Load Regulator
Fig. 5-4

For the purpose of load regulation, the engine horsepower output is determined by the rate of fuel consumption. Thus, for each position of the throttle there is a definite rate of fuel consumption when the engine is loaded. The rate of fuel consumption is related to the position of the governor power piston, which controls the opening of the injector racks. If the load on the engine should be such that more fuel is demanded (to rotate the engine at the RPM "ordered" by the throttle) than the predetermined balance point (between load and fuel consumption), the load regulator pilot valve will cause the load regulator to reduce the engine load the required amount by reducing the battery field strength.

If the engine requires less fuel than the predetermined setting, the load regulator increases the load on the engine by increasing the battery field excitation of the main generator. In this manner, battery voltage, temperature changes in the generator windings, or locomotive speeds do not cause overloading or underloading of the engine and a constant power output is maintained for each throttle setting.

An overriding solenoid, ORS, in the governor, is energized whenever the battery field contactor is open; such as whenever the throttle is in idle, during transition from 3 to 2 or 2 to 3, or during wheel slip action. The energizing of this solenoid causes the load regulator to move into or toward the minimum field position, depending upon the length of time that the ORS is energized, unloading the engine.

Another switch that can energize the ORS is the overload micro-switch (OLS) located in the governor. The OLS is actuated whenever the engine is overloaded; energizing the ORS to bring the load regulator toward minimum field position, reducing the load on the engine.

507 **Engine Speed Control** The throttle lever, in the controller, has ten positions: STOP, IDLE and RUNNING SPEEDS 1 THROUGH 8. Each throttle step, from 2 through 8, increases the engine speed 80 RPM.

The governor directly controls the engine speed but does so according to the "orders" of the throttle.

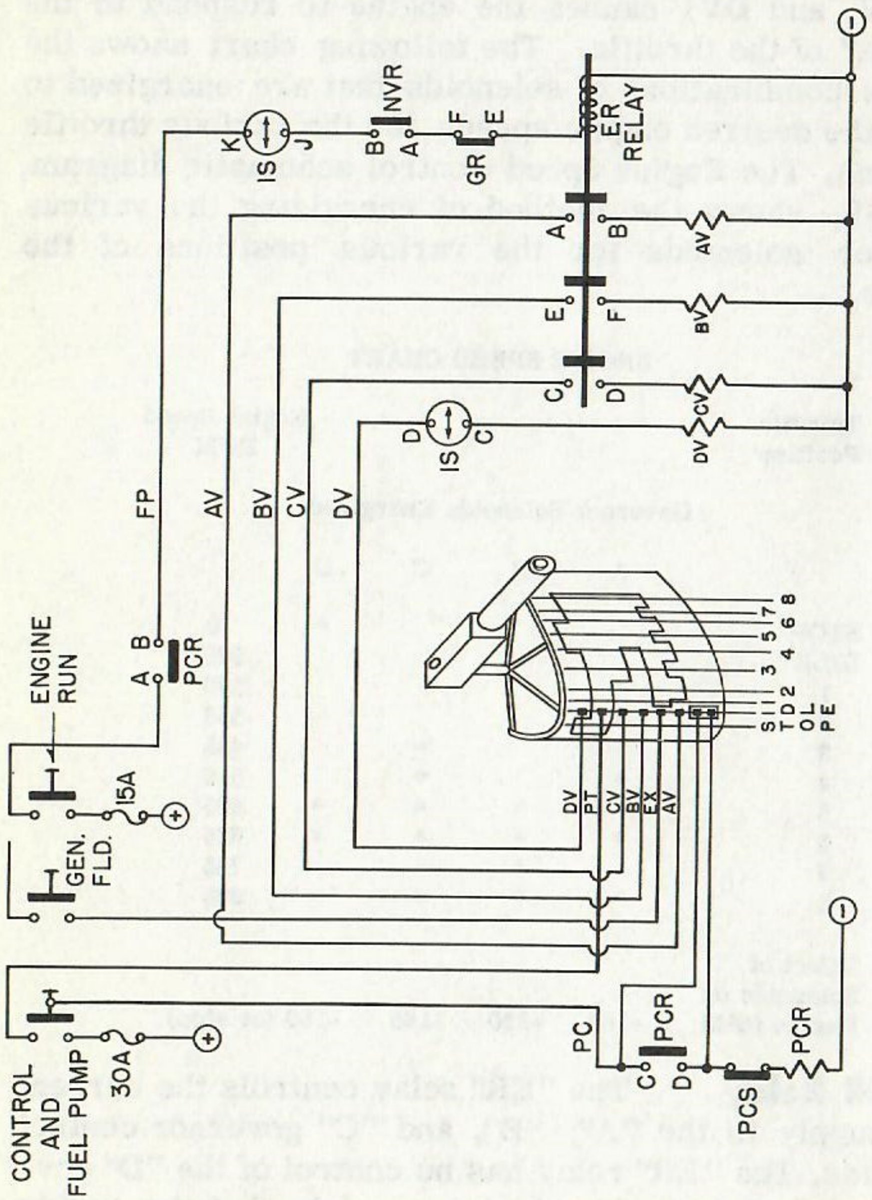
The throttle lever operates a drum type switch which has the ability to distribute current from a "hot wire" to one or more other wires, depending on the position of the throttle.

The governor is designed so that the energizing of various combinations of four governor solenoids (AV, BV, CV, and DV) causes the engine to respond to the "orders" of the throttle. The following chart shows the various combinations of solenoids that are energized to obtain the desired engine speeds for the various throttle positions. The Engine Speed Control schematic diagram, Fig. 5-5, shows the method of energizing the various governor solenoids for the various positions of the throttle.

**ENGINE SPEED CHART**

| Throttle Position | Governor Solenoids Energized | | | | Engine Speed RPM |
|---|---|---|---|---|---|
| | A | B | C | D | |
| STOP | | | | * | 0 |
| IDLE | | | | | 275 |
| 1 | | | | | 275 |
| 2 | * | | | | 355 |
| 3 | | | * | | 435 |
| 4 | * | | * | | 515 |
| 5 | | * | * | * | 595 |
| 6 | * | * | * | * | 675 |
| 7 | | * | * | | 755 |
| 8 | * | * | * | | 835 |
| Effect of Solenoids on Engine RPM | +180 | +320 | +160 | -160 (or stop) | |

508 **ER Relay** The "ER" relay controls the current supply to the "A", "B", and "C" governor control solenoids. The "ER" relay has no control of the "D" governor control solenoid, which is used to shut the engine down. The "D" solenoid is energized in throttle positions STOP, Run 5 and Run 6. De-energizing the "ER" relay with the throttle in Run 5 or 6, will cause the engine to shut down. De-energizing the "ER" relay in any



Engine Speed Control
Fig. 5-5

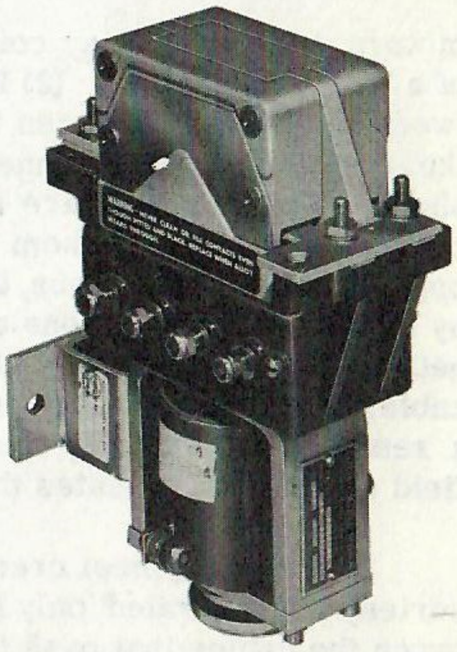
other throttle position will automatically reduce the speed of the engine to IDLE.

To control the engine speed in any unit, the "ER" relay in that unit must be energized. The "ER" relay has three normally open interlocks which will close, when the relay is energized, to connect the control circuits to the "A", "B", and "C" governor control solenoids, Fig. 5-5.

The "ER" relay in each unit is energized by current received from the "FP" wire that runs throughout the locomotive. To energize the "FP" wire and the "ER" relay, the "Engine Run" switch in the operating cab must be IN, the ground relay must be set, the "PC" switch must be closed ("PC" light out), the isolation switch must be in RUN and the "NVR" relay must be energized (engine must be running).

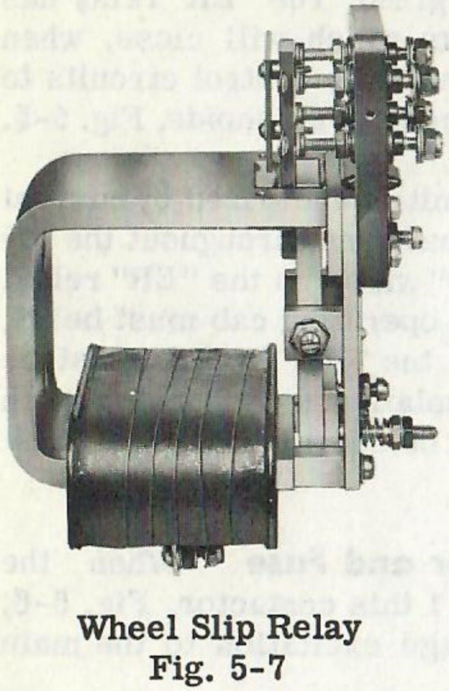
509 **Battery Field Contactor and Fuse** When the throttle is moved to Run 1 this contactor, Fig. 5-6, closes and connects low voltage excitation to the main generator battery field. The battery field contactor remains closed as long as power is being applied, but will open during transition 2 to 3 and 3 to 2 and wheel slip action to reduce main generator output. A rectifier and discharge resistor are used to dissipate the high voltage induced in the battery field when the BF contactor is opened.

An 80 ampere battery field fuse, located in the low voltage panel protects the battery field circuit. If the fuse is blown the unit will not develop normal power.



Battery Field Contactor
Fig. 5-6

510 **Wheel Slip Control** The wheel slip control system goes into operation the moment that the slipping of a pair of wheels is detected while under power. Four wheel slip control relays, WSR13, WSR24, WSS, and WCR, located in the electrical cabinet, are of the through-cable type, Fig. 5-7.



Wheel Slip Relay
Fig. 5-7

The WSR relays are operated by two sources: (1) By a flow of current through the relay coil with the traction motors connected in series-parallel or series-parallel shunt. Current will flow through the relay coil, when an unbalance in the bridge circuit between two 2000 ohm resistors and two traction motors, which the relay coil bridges, occurs as a result of a "slipping" motor. (2) By a current differential between the cables that pass through the relay frame with the traction motors connected in parallel or parallel shunt. These cables are so arranged that the normal current flow through them is of equal magnitude and in opposite directions. Thus, the magnetic field established by the current flow in one cable is nullified by the magnetic field established by the current flow in the second cable. When an unbalance in the current flows occurs as a result of a "slipping" motor, the resultant magnetic field established actuates the WSR.

The WCR (wheel creep relay) and WSS (wheel slip series) are operated only by a current differential between the cables that pass through the relay frame, with the traction motors connected in series parallel or series parallel shunt.

Automatic sanding in power occurs through the action of the WCR relay. The WCR is used to detect very slow creeping type slips. The function of the WCR, having a slightly lower pickup value than the WSS and WSR, is to apply sand automatically to the rails which tends to prevent a wheel slippage necessitating the reduction of generator field excitation.

When WCR picks up, it energizes the time delay sanding relay (TDS). "Picking up" of the TDS automatically actuates the forward sanding valve, applying sand to the rail.

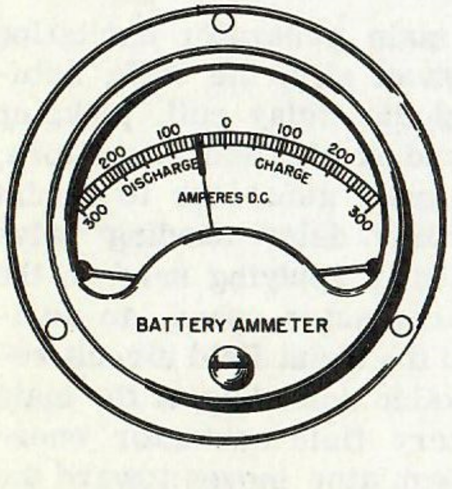
At very slow speeds, if the wheel slip cannot be corrected through the action of the WCR applying sand to the rails, the WSS picks up to reduce main generator excitation. When the WSS picks up, the wheel slip light will flash ON and the battery field contactor (BF) will open. Opening the battery field contactor, "cuts out" the main generator battery field excitation and causes the overriding solenoid (ORS) to move the load regulator toward the minimum field position. This action will generally correct the wheel slip, and it should not be necessary for the enginemen to reduce the throttle. The function of the WSS relay is to recognize slow speed wheel slips and effect a slip correction with a minimum loss of tractive effort.

If further reduction of main generator excitation is necessary to correct the wheel slip, the WSR, actuated by a current flow through the relay coil, picks up and opens both the battery and shunt field contactors, reducing the excitation of the main generator to a point where slipping stops. The time delay sanding valve (TDS) is energized, automatically applying sand to the rails. When the shunt field contactor opens, an additional resistance is added into the shunt field circuit resulting in a further but controlled unloading of the main generator. Opening the battery field contactor energizes the ORS, and the load regulator moves toward the minimum field position. Thus, as soon as the slipping stops, the WSR relay will drop out, and power will automatically be reapplied at a lower level than that at which the slipping was initiated. The application of power will then gradually return to that designated by the position of the throttle.

To correct high speed wheel slips with the traction motors connected in parallel or parallel shunt, either of the WSR relays, actuated by a current differential between traction motors 1 and 3 (WSR 13) or 2 and 4 (WSR 24) will pick up to reduce main generator excitation to a point where slipping stops.

Since sand is automatically applied to the rails during a wheel slip detection, it should be unnecessary for the enginemen to operate the manual sanders. If continuous wheel slipping on sand occurs, the throttle should be reduced.

511 **Main Battery Switch** This switch is located on the distribution panel and connects the 32 cell, 64 volt, 426 ampere-hour capacity (8 hour rating) battery to the low voltage circuits. An external charging receptacle is located on the left side of the locomotive. To start the Diesel engine and during normal locomotive operation, the main battery switch should be closed.



Battery Ammeter
Fig. 5-8

512 **Battery Ammeter** The battery ammeter is visible through an opening on the front side of the electrical cabinet. This ammeter, Fig. 5-8, only shows whether the battery is charging or discharging. Normally the meter will indicate zero or a slight charge. If a continual discharge is shown, the auxiliary generator output should be checked, or the battery may run down.

513 **Reverse Current Relay** This relay, Fig. 5-9, located on the low voltage panel, controls the opening and closing of the battery charging contactor (BC). The RCR causes the BC contactor to open when the auxiliary generator voltage drops below the battery voltage. This prevents a reverse flow of current from the battery attempting to "motor" the auxiliary generator.

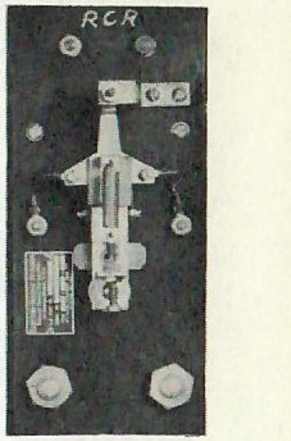
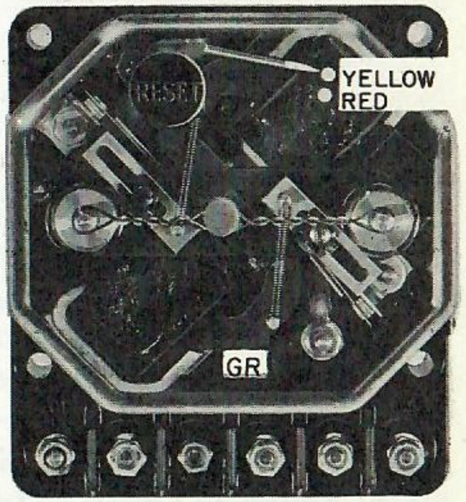


Fig. 5-9

514 **Battery Charging Contactor** This contactor is an electrically operated switch connecting the auxiliary generator output to the low voltage system. The reverse current relay controls the operation of the battery charging contactor.

515 **Ground Relay** The ground relay, Fig. 5-10, located in the electrical cabinet, is an electrical protective device connected to the high voltage system. The function of this relay is to unload the main generator automatically in case of a ground in the high voltage system (a ground can be defined as a current passing through the frame, or carbody, of the locomotive.)

If a ground in the high voltage system should occur, the ground relay will trip. When tripped, the ground relay opens the shunt and battery field contactors, unloading the main generator. The ground relay must be reset before the unit can again deliver power. The relay is reset by pressing in on the reset button on the relay. Should



Ground Relay
Fig. 5-10

the relay repeatedly trip when power is applied, the power plant MUST be isolated.

CAUTION: Isolate unit before resetting the ground relay.

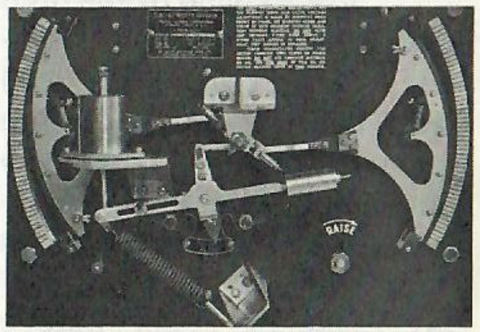
If the ground relay trips, the white needle in the relay will point to a red dot. In the normal position the needle points to a yellow dot.

With ground relay tripped, the speed of the engine will be automatically reduced to Idle. If the ground relay tripped while the throttle was in the 5th or 6th notch, the engine would stop.

Although a high voltage ground will normally be the only reason for the ground relay tripping, a low voltage ground can trip the relay when the engine is started; since at that time the high and low voltage systems are temporarily connected. Ground relay action is not necessarily an indication of serious trouble but should be reported to the maintenance authorities.

The ground relay knife switch, when open, eliminates the protection of the ground relay. This switch MUST NOT BE OPENED in normal operation unless definite instructions are issued by an official of the railroad.

516 **Voltage Regulator** The voltage regulator, Fig. 5-11, is located in the electrical cabinet. The voltage regulator performs the function of seeing that the output voltage of the auxiliary generator remains at approximately 74 volts whenever engine is running.

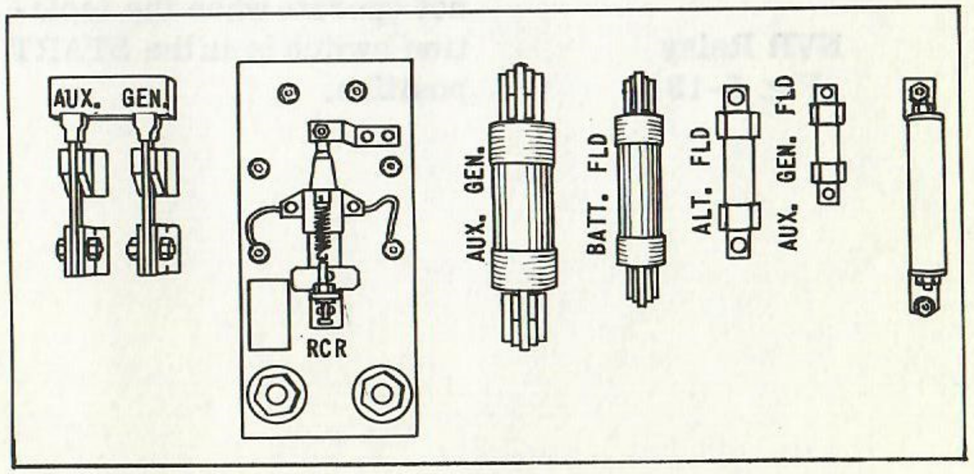


Voltage Regulator
Fig. 5-11

517 **Auxiliary Generator Fuse** (Battery Charging) This fuse, Fig. 5-12, located on the low voltage panel, protects the auxiliary generator against any possible overload. A blown auxiliary generator output fuse will cut off the auxiliary generator from the low voltage system and the alternating current system. The battery ammeter will indicate a discharge when this fuse is blown, the alarm bell will ring, and the "Alternator Failure" light (blue) will flash on in the unit affected.

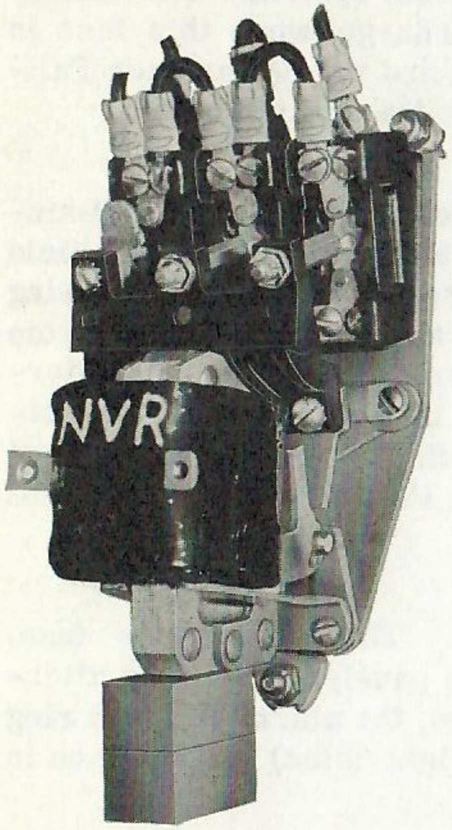
518 **Auxiliary Generator Field Fuse** This 30-ampere fuse protects the auxiliary generator field windings against excessive current, Fig. 5-12. Blowing of this fuse will prevent the auxiliary generator from supplying current to the low voltage system and alternating current system. With this fuse blown, the battery ammeter will indicate a discharge, the alarm bell will ring, and the "Alternator Failure" light (blue) will flash on in the unit affected.

519 **Alternator Field Fuse** This 30-ampere fuse, located on the low voltage panel, protects the alternator field, Fig. 5-12. If blown, the alarm bell will ring and the "Alternator Failure" light (blue) will flash on in the unit affected.



Low Voltage Panel
Fig. 5-12

520 **No AC Voltage Relay** ( NVR ) As the traction motors are cooled by AC driven blowers, failure of the alternator could result in damage to the traction motors unless the application of power was stopped. Thus, in case of an alternator failure, the NVR, Fig. 5-13, located on the low voltage panel, drops out and causes the alarm bell to ring in all units. The "Alternator Failure" light (blue) will flash on, and the engine speed will be reduced to idle in the unit affected (if the throttle was in the 5th or 6th notch the engine would stop.)



NVR Relay
Fig. 5-13

The "NVR" dropping out can be caused by (1) engine stopped, (2) auxiliary generator fuse (battery charging) blown, (3) auxiliary generator field fuse blown, or (4) alternator field fuse blown. The alternator failure alarm will not operate when the isolation switch is in the START position.

# SECTION 6

## STEAM GENERATOR

### OK-4740, OK-4635, OK-4630, OK-4625 AND OK-4616

## INTRODUCTION

The instructions contained in this section are for the guidance of personnel engaged in the operation of OK series steam generators. A general description of the steam generator is given, the operating technique is outlined and a trouble shooting section is provided for the operator.

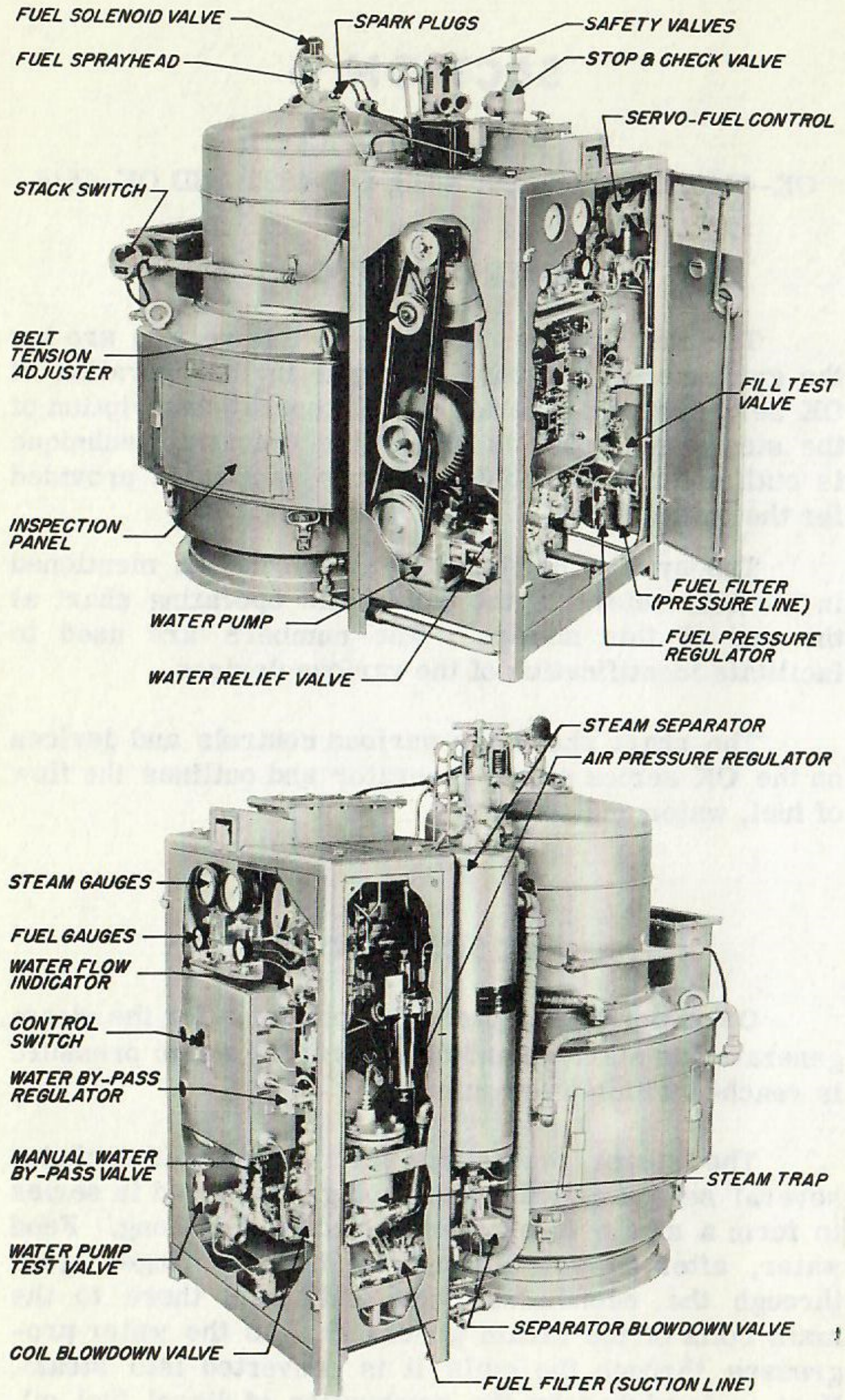
The symbol number after each device mentioned in the text refers to the schematic operating chart at the end of this section. The numbers are used to facilitate identification of the various devices.

The chart shows the various controls and devices on the OK series steam generator and outlines the flow of fuel, water and steam.

## DESCRIPTION

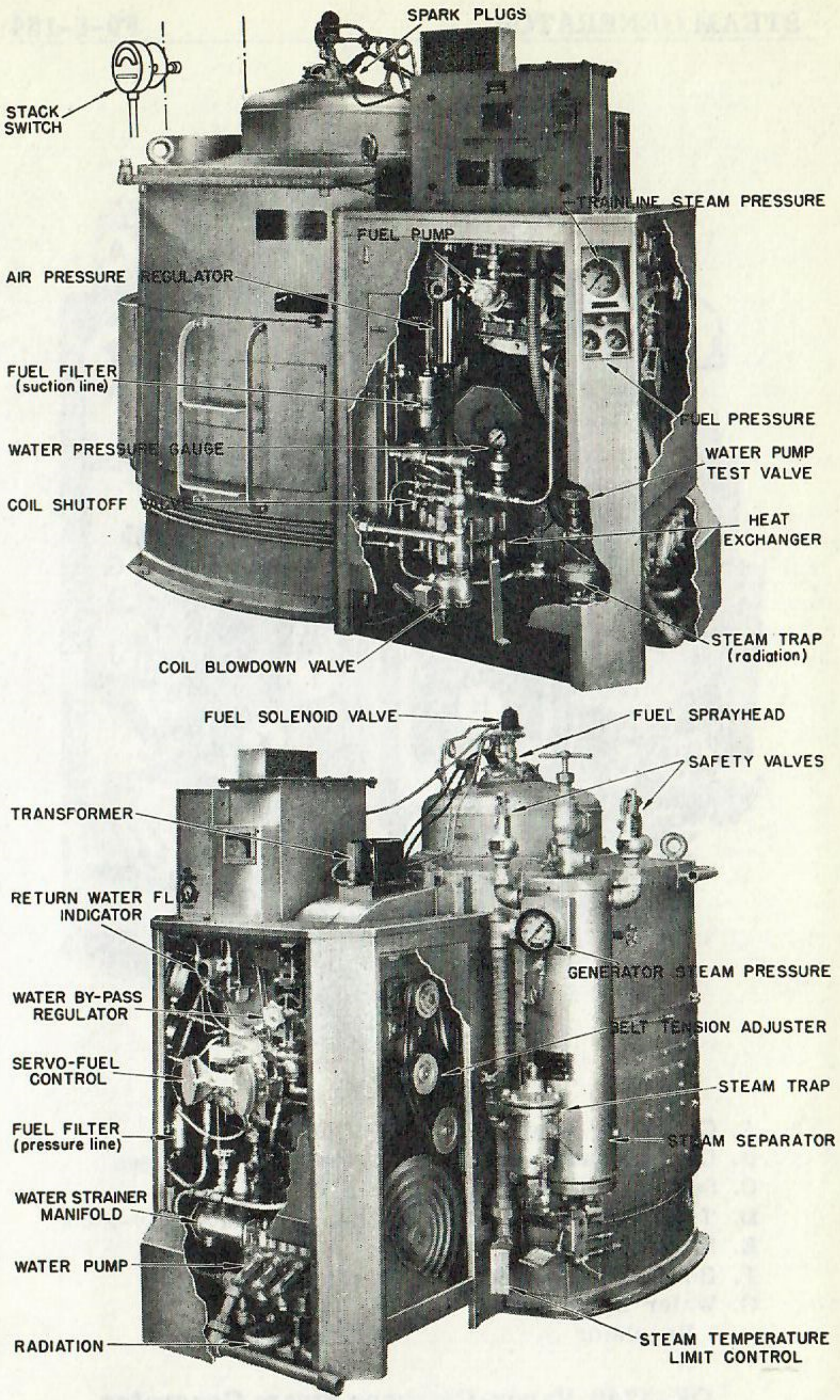
Operation is completely automatic after the steam generator is started, and full operating steam pressure is reached within a few minutes.

The steam generating part of the unit includes several sets of coiled water tubing, connected in series to form a single tube several hundred feet long. Feed water, after passing through the heat exchanger, goes through the economizer coil and from there to the main coils of the steam generator. As the water progresses through the coils it is converted into steam. Heat is furnished by the combustion of diesel fuel oil, which is sprayed by compressed air through the atom-


FUEL SOLENOID VALVE
FUEL SPRAYHEAD
SPARK PLUGS
SAFETY VALVES
STOP & CHECK VALVE
SERVO-FUEL CONTROL
STACK SWITCH
BELT TENSION ADJUSTER
FILL TEST VALVE
INSPECTION PANEL
FUEL FILTER (PRESSURE LINE)
WATER PUMP
FUEL PRESSURE REGULATOR
WATER RELIEF VALVE
STEAM SEPARATOR
AIR PRESSURE REGULATOR
STEAM GAUGES
FUEL GAUGES
WATER FLOW INDICATOR
CONTROL SWITCH
WATER BY-PASS REGULATOR
MANUAL WATER BY-PASS VALVE
STEAM TRAP
WATER PUMP TEST VALVE
SEPARATOR BLOWDOWN VALVE
COIL BLOWDOWN VALVE
FUEL FILTER (SUCTION LINE)

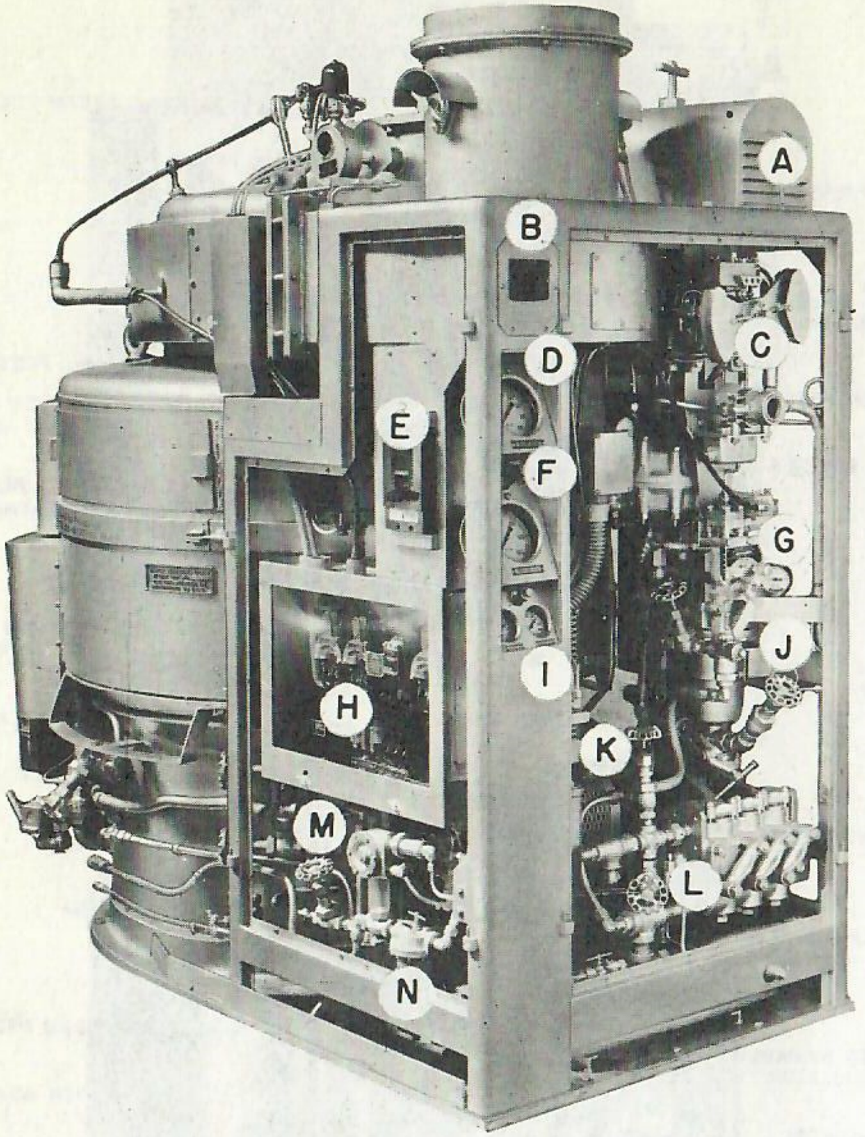
**OK-4625 Vapor-Clarkson Steam Generator**

**Fig. 6-1a**


SPARK PLUGS
STACK SWITCH
TRAINLINE STEAM PRESSURE
FUEL PUMP
AIR PRESSURE REGULATOR
FUEL FILTER (suction line)
FUEL PRESSURE
WATER PRESSURE GAUGE
WATER PUMP TEST VALVE
COIL SHUTOFF VA
HEAT EXCHANGER
STEAM TRAP (radiation)
COIL BLOWDOWN VALVE
FUEL SOLENOID VALVE
FUEL SPRAYHEAD
SAFETY VALVES
TRANSFORMER
RETURN WATER FL INDICATOR
GENERATOR STEAM PRESSURE
WATER BY-PASS REGULATOR
BELT TENSION ADJUSTER
SERVO-FUEL CONTROL
STEAM TRAP
FUEL FILTER (pressure line)
STEAM SEPARATOR
WATER STRAINER MANIFOLD
WATER PUMP
STEAM TEMPERATURE LIMIT CONTROL
RADIATION

**OK-4630 Vapor-Clarkson Steam Generator**

**Fig. 6-1b**



A. Converter Housing
B. Control Switch
C. Servo Fuel Control
D. Trainline Press. Gage
E. Main Switch
F. Boiler Press. Gage
G. Water By-Pass Regulator
H. Control Panel
I. Fuel Press. Gages
J. Fill Test Valve
K. Manual Water By-Pass Valve
L. Water Pump
M. Fuel Pump
N. Fuel Filter

**OK-4740 Vapor-Clarkson Steam Generator**
**Fig. 6-1c**

izing nozzle in the fuel spray head-105 into the firepot above the coils. Here the fine oil spray mixes with air supplied by the blower-202, and is ignited by a continuous electric spark-220. The hot gases flow, first downward, then up and outward through the coils, finally flowing out the stack.

The supply of fuel is regulated to evaporate approximately 90% of the water pumped through the coils. The excess water flushes scale and sludge from the coils and is carried over with the steam into the steam separator-221, where the water and sludge are separated from the steam.

The excess water collects in the bottom of the steam separator. Water above the level of the return outlet flows out through a steam trap-223 and through the heat exchanger-213, where it gives up its heat to the incoming feed water. From the heat exchanger the return water flows through return water flow indicator-218 back to the water supply tank-232.

The motor converter-215 drives the blower-202, water pump-230 and fuel pump-209 at a constant speed. The water by-pass regulator-111 automatically controls steam generator output by regulating the amount of water fed to the coils. Before entering the coils, the water passes through servo-fuel control-108, which admits fuel to the spray nozzle in direct proportion to the amount of water entering the coils. The servo-fuel control also adjusts the damper-203 to admit the proper amount of air for proper combustion of the fuel.

The trainline steam pressure is regulated by adjusting the setting of the water by-pass regulator-111. The length of train and the weather conditions determine the setting.

## BEFORE STARTING

The valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle.

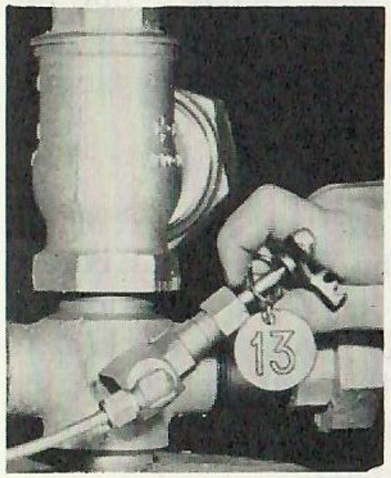
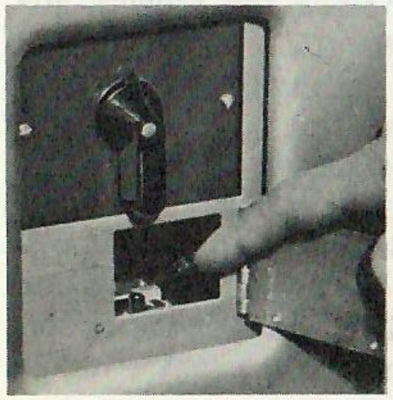


Fig. 6-2

1. Make certain that the following valves are OPEN:
   - Atomizing Air Shutoff Valve-1
   - Coil Shutoff Valve-3
   - Return Water Outlet Valve-9
   - Trainline Cross-Over Valve-11
   - Steam Admission Valve-13 to Water By-Pass Regulator-11
   - Three-Way Washout Valve-17
   - Water By-Pass Regulator Shutoff Valve-19
   - Water Supply Stop Valve-21



Overload Reset
On OK-4625
Fig. 6-3

2. Be sure that the following valves are CLOSED:
   - Coil Blowdown Valve-2
   - Layover Connection Shutoff Valve-6
   - Manual Water By-Pass Valve-8
   - Return Line Valve (Standby)-56
   - Steam Admission Valve-10 to Radiation-217 (open in cold weather operation).
   - Washout Inlet Valves-14-16
   - Water Pump Test Valve-18
   - Water Drain Valves-20 and 22
3. Both overload reset button-106 and stack switch-109 reset button must be "In." The overload reset button is located on the magnetic overload relay, Fig. 6-3.

## TO FILL

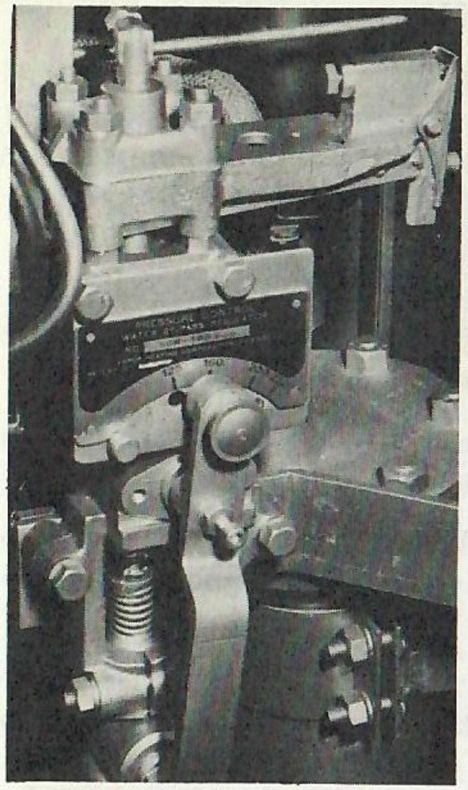
1. Open the atomizing air shutoff valve-1 and fill-test valve-4; latch open the separator blowdown valve-12 to drain the steam separator. Close the separator blowdown valve when the separator is completely drained.
2. Close the main switch and turn the control switch-102 to FILL. If the coils are empty it will take about five minutes to fill the steam generator with water.
3. While the coils are filling see that spark-220 is available for ignition. Check ALL valves.
4. When water discharges from the fill-test valve-4 turn the control switch-102 to OFF and close the fill-test valve.

NOTE: The water pump, being a high pressure pump will apply an undesirable hydrostatic pressure to the steam generator, gauges and controls, unless the control switch is immediately placed in the OFF position when water discharges from the fill-test valve.

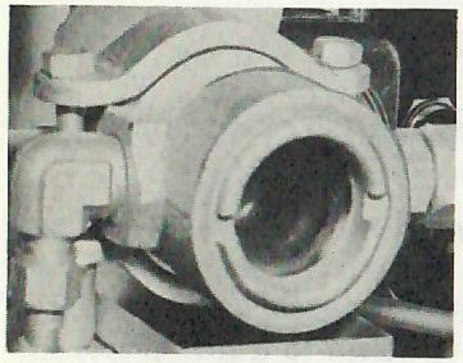
## TO START

CAUTION: Do not start the steam generator unless the coils are filled.

1. Latch open the separator blowdown valve-12 and turn the control switch-102 to RUN. (For easy starting, be sure the control switch has been OFF long enough for the motor to come to a full stop.)
2. Close the separator blowdown valve-12 when the generator steam pressure gauge-212 registers approximately 150 pounds.
3. OPEN THE SEPARATOR BLOWDOWN VALVE SEVERAL TIMES FOR THREE TO FIVE SECOND INTERVALS DURING THE FIRST FEW MINUTES OF OPERATION.



Water By-Pass Regulator
Fig. 6-4



Return Water
Flow Indicator
Fig. 6-5

4. Set the water by-pass regulator-111, Fig. 6-4, to the required trainline pressure.
5. After the trainline is coupled, open the remote control trainline shutoff valve-7 (if used) by depressing the reset lever-7a. Then slowly open the trainline stop (shutoff) valve-15.

NOTES:

1. Check the return water flow after the steam generator has settled down to a steady output. The return flow water indicator-218, Fig. 6-5, should cycle from 4 to 12 times a minute on 3000 lb. units; from 4 to 10 times a minute on 2500 lb. units, and from 4 to 8 times a minute on 1600 lb. units.
2. If the steam generator does not start or function properly, check all valves to see that they are open or closed as indicated in the operation chart.
3. The steam generator should come up to full operating pressure in 2 or 3 minutes. It may take 10 to 15 minutes to build up the required operating steam pressure in the trainline, depending upon train length and trainline condition.

## STANDBY HEATING

(If Used)

Standby heating is applied to the locomotives to prevent freeze-up of the steam generator and its water supply tank at times when the steam generator is not required to make steam. In brief, the generator operates with an amount of fuel sufficient to heat the water but not to make steam, and circulates this hot water through the generator and supply tank.

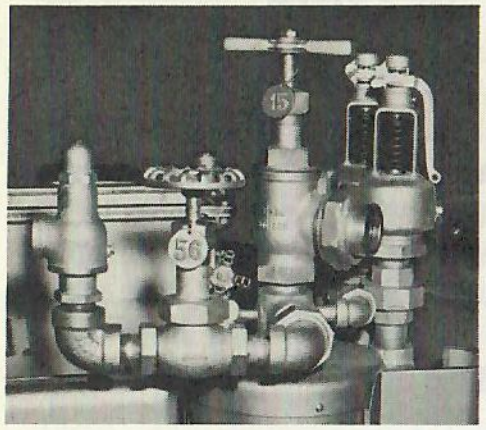
When the control is switched to "Standby," the unit operates at low fire under control of an aquastat with full circulation of water through the coils, cycling "on" when the water temperature drops to 100° F., and cycling "off" at 135° F. During the "off" cycle the warm water is circulated through the system by a small circulating pump.

Low fire operation on "Standby" is obtained through the automatic burner adjusting control and the three-way solenoid valve. The burner control has a spring-loaded, hydraulic piston mechanism which controls the position of the metering pin in the servo. During normal operation, fuel pressure against this piston holds the metering pin up in its operating position.

On "Standby" the solenoid valve relieves the fuel pressure on the piston; spring tension then forces the piston down and holds the metering pin below its normal operating position, thus changing the delivery ratio of water to fuel and combustion air. Maximum water flow is maintained, but air and fuel flow into the combustion chamber is reduced to low-fire proportions.

Standby Operation:

1. Set the water by-pass regulator-111 for maximum pressure.
2. Close the stop-check valve-15.



Valves 56 and 15
Fig. 6-6

3. Close steam trainline pressure gauge line valve-11.
4. Open standby water return line valve-56 located at top of steam separator below stop-check valve-15, Fig. 6-6.
5. Open the radiation heating valve-10 and the layover connection shutoff valve-6 to allow the heated water to flow through the protective heating system.
6. Turn the Control switch-102 to "Standby" position.

Return To Normal Operation:

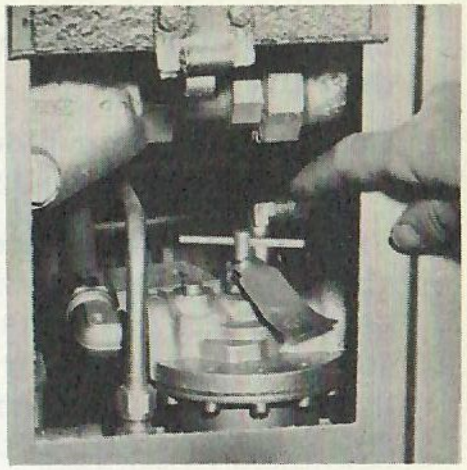
1. Close standby return line valve-56, radiation heating valve-10 (open in cold weather operation), and layover connection shutoff valve-6.
2. Open the separator foot valve and drain excess water from boiler coils, following the normal procedure for firing a boiler.
3. Place the control switch in "Run" position. When steam pressure reaches 150 psi, close separator foot valve, open stop-check valve-15.
4. Set water by-pass regulator at desired pressure.
5. Open steam trainline pressure gauge valve-11.

## RUNNING ATTENTION

1. Open the separator blowdown valve-12 at least once every hour. (Except when in standby operation, if used). Frequent blowdowns will reduce the tendency for sludge to accumulate.

2. Turn the handle on the fuel filter-206, Fig. 6-7, during stops. At the same time, turn the handle on the treatment injector filter-225, where this method of water treatment is used.

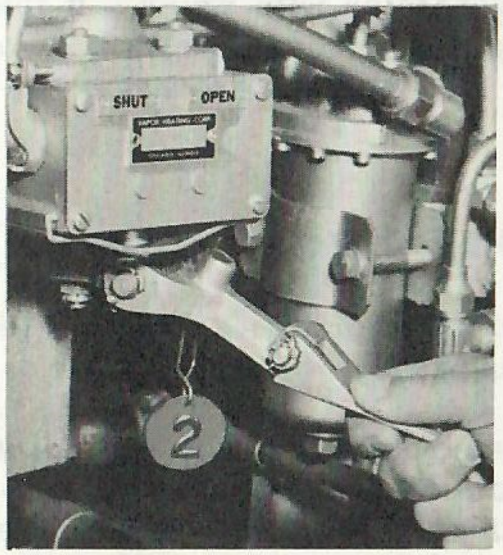
CAUTION: Trainline remote control valve-7 (when used) and/or stop and check valve-15 must be closed when shutting off trainline steam.



Suction Line Fuel Filter
Fig. 6-7

## TO SHUT DOWN THE STEAM GENERATOR

For short stops it is only necessary to close the stop and check valve-15. The fire will cycle and maintain operating pressure in the steam generator. For terminal stop, proceed as follows:



Coil Blowdown Valve 2
Fig. 6-8

1. Close the stop and check valve-15 and the remote control trainline shutoff valve-7 (if used).
2. Set the water by-pass regulator-111 to maximum output. When the generator steam pressure gauge-212 registers 200 pounds turn the control switch-102 to OFF.
3. Open the coil blowdown valve-2, Fig. 6-8. When

the generator pressure drops to 75 pounds, close the valve.

4. Open the separator blowdown valve-12 and blow down the steam separator-221 with the remaining pressure.
5. Fill the coils with water according to the procedure given on Page 606, with the exception that it will be found advantageous to fill a "hot" steam generator with the separator blowdown valve latched open, thereby purging the coils while also eliminating the discharge of steam at the fill test valve.
6. Close the atomizing air shutoff valve-1 and open the main switch.

## LAYOVER OPERATION

1. Open steam admission valve to radiation-10.
2. Open layover connection shutoff valve-6.

NOTE: When starting, do not omit draining the steam separator, opening the fill-test valve, and again filling the steam generator with water. If the coils are already full, it will only take a moment for water to discharge from the fill-test valve.

## FREEZING WEATHER PRECAUTIONS

The inlet valve-10 to the radiation-217 should be opened when operating during severe weather.

If a locomotive consist does not have all of its steam generators in operation, open the layover connection shutoff valve-6, the trainline pressure gauge steam admission valve-11, and the inlet valve-10 to the radiation on idle steam generators. Be sure coil blowdown valve-2 and stop and check valve-15 are closed.

If a locomotive is left standing out of service, operate one of the steam generators or make a connection to the yard steam line.

If no steam at all is available, thoroughly drain the steam generator. Open the drain valves-20 and 22, the water pump test valve-18, the coil blowdown valve-2, the separator blowdown valve-12 and the coil shutoff valve-3. Break the pipe connections where necessary to completely drain the piping. Turn the water pump by hand to clear it of water, or blow it out with compressed air. Remove the cover of the water treatment or water strainer tank-234 and make sure it is drained.

## TROUBLE SHOOTING

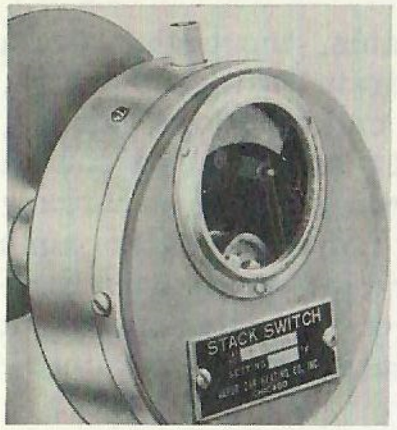
If one of the protective switches (magnetic overload relay, coil blowdown switch or stack switch) operates to shut down the steam generator, the alarm will ring and the GREEN "boiler off" signal will light.

Turn the control switch-102 to OFF and use the following instructions as a guide in locating the trouble.

### Motor And Burner Shut Down During Operation

1. Blown fuses: The alarm will not ring and the instrument lights will go out. The main fuse (or circuit breaker) is generally located in the electrical cabinet of the locomotive. Check this fuse, and check the control fuses in the steam generator control cabinet. A test lamp and fuse clips wired inside the electrical cabinet may be used to check the fuses.
2. Overload reset button-106 "out:" The alarm will ring; the instrument lights will remain on. Turn the control switch-102 OFF; check for hot blower-202

or water pump-230 bearings and for poorly adjusted pulley belts. Check the setting of the belt tension adjuster. Push the overload reset button "IN."



Stack Switch
Fig. 6-9

3. Stack switch-109, Fig. 6-9, reset button "OUT." Stack switch high temperature contacts are open. The alarm rings, instrument lights remain on. Turn control switch-102 to "OFF"; open the separator blowdown valve-12 and drain steam separator. Push in stack switch reset button. Open Fill-Test valve-4 and turn control switch to "FILL." When water discharges from Fill-Test valve, turn control switch to "OFF," close Fill-Test valve and start steam generator as usual.

4. Coil blowdown valve-2 partially open: The alarm rings, instrument lights remain on. Turn the control switch to OFF. Be sure that the coil blowdown valve handle is properly seated in the closed position, then start as usual.

5. Air switch-101 contacts open: The alarm sounds, instrument lights remain on. Turn control switch off. Be sure that the air admission valve-1 is fully open. Clean the strainer screen in the air line, and drain the air pressure regulator-100. If the low atomizing air pressure persists, increase the pressure by turning the regulator adjusting screw clockwise. When air pressure is restored, start as usual.

### Motor Starts But Burner Does Not

If the fire fails to light the low temperature contacts on the stack switch-109 will not close and after a 45 second time delay the outfire relay will open the circuit to shut down the steam generator. The alarm will ring and the instrument lights will remain on. Turn the control switch-102 OFF and check the following instructions for possible causes for the burner failure.

1. Ignition failure: Turn control switch to FILL -- no spark visible through the peep hole glass, or spark is of low intensity. If an ignition fuse is blown or if the current flow is broken for any other reason, the ignition circuit will be inoperative. If the spark plug electrodes are dirty or too far apart or if the electrodes are too close together, the ignition circuit will not operate properly.

   Check the ignition fuses -- use the test lamp and clips installed in the electrical cabinet for that purpose. Tighten loose cable connections and replace chafed or broken wire which may be breaking or grounding the circuit.

2. Low atomizing air pressure-201: The air switch-101 opens and breaks the circuit to the fuel solenoid valve-104, which then stops the flow of fuel to the sprayhead-105.

   Be sure the air admission valve is fully open. Clean the strainer screen in the atomizing air line and drain the atomizing air pressure regulator-100. If the low atomizing air pressure persists, tighten the adjusting screw at the top of the air pressure regulator to increase the atomizing pressure.

3. Low fuel manifold pressure-208: Turn the handle on the suction line fuel filter-206 several times. A slight suction leak may cause the manifold pressure to build up slowly; put the control switch-102 on FILL to bleed the fuel line and bring the manifold pressure up to normal.

4. Low fuel nozzle pressure-207: Lack of water causes the servo fuel control-108 to limit the supply of fuel entering the nozzle. (If the water supply is almost

completely stopped, the cam plate may come down far enough to actuate the cutout switch on the servo and close the fuel solenoid valve-104.)

Be sure that the pump belts have proper tension, the water pump test valve-18 is closed, the cover on the water treatment or strainer tank-234 is tight, the three-way washout valve-17 is fully open, and that the drain valves-20 and 22 are tightly closed.

Open and close the water by-pass regulator-111 adjusting handle several times to free the regulator from possible sediment. If the water pressure gauge-229 still registers low, close the water by-pass regulator shutoff valve-19. This closes the water by-pass line and permits all of the feed water to flow to the servo-fuel control-108; the steam generator will start at once if the by-pass regulator is causing the trouble. Set and manually regulate the trainline steam pressure by adjusting the manual water by-pass valve-8.

High feed water temperature or leaky water line connections may cause the water pump-230 to become air or vapor bound. Violent fluctuation of the water pressure gauge needle indicates this condition. Tighten leaky water line connections and bleed the line by opening the water pump test valve-18. Allow water to flow from this valve until no air or vapor bubbles are evident in the water.

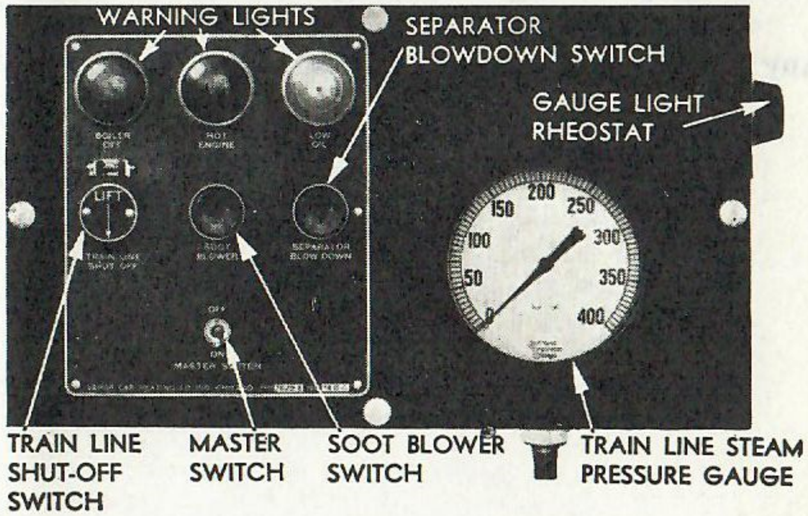
### Irregular Trainline Pressure

1. Burner cycles off and on: Insufficient water delivery causes the steam generator to run in superheat; the steam temperature limit control-110 operates to protect the coils against overheating. Check the water pump output as instructed in the preceding paragraphs.

2. Safety valves blow: Shut down the steam generator. Lower the trainline pressure setting on the adjusting handle of the water by-pass regulator-111 and start the steam generator again. If the safety valves-107 continue to pop, close the water by-pass regulator shutoff valve-19 and manually regulate the trainline steam pressure by opening and adjusting the manual water by-pass valve-8.

## REMOTE CONTROL EQUIPMENT

The remote control panel is located on the fireman's side of the locomotive cab. Mounted on it are a master switch to make the panel operative, and push-button switches to operate the separator blowdown valve-12 and the remote control trainline shutoff valve-7. Three warning lights are mounted in the panel and may be connected to the alarm circuit of the locomotive. The lights are marked "boiler off," "hot engine" and "low oil." A trainline steam pressure gauge is mounted on the panel.


WARNING LIGHTS
SEPARATOR BLOWDOWN SWITCH
GAUGE LIGHT RHEOSTAT
BOILER OFF
HOT ENGINE
LOW OIL
LIFT
TRAIN LINE SHUT OFF
SOOT BLOWER
SEPARATOR BLOW DOWN
OFF
ON
MASTER SWITCH
0
50
100
150
200
250
300
350
400
TRAIN LINE SHUT-OFF SWITCH
MASTER SWITCH
SOOT BLOWER SWITCH
TRAIN LINE STEAM PRESSURE GAUGE

Remote Control Panel
Fig. 6-10

The remote control trainline shutoff valve-7 can be closed from the cab; but must be opened manually. Depress the reset lever-7a on the trainline shutoff valve-7 to the position marked open."

## ITEMS TO REPORT

1. Water pressure greater than 100 pounds above normal.
2. Excessive stack temperature.
3. Fluctuation of the fuel manifold pressure.
4. Frequent cycling of the burner.
5. Water flow indicator not cycling.
6. Water by-pass regulator inoperative.
7. Any faulty operation of the steam generator.

### VAPOR HEATING OK-SERIES STEAM GENERATOR TROUBLE SHOOTING CHART

| Symptoms | Cause of Trouble | Remedy |
|---|---|---|
| Panel lights do not light; bell does not ring (Control switch "OFF" main boiler switch "ON") | Main battery switch "OPEN" | Close |
| | Auxiliary generator switch "OPEN" | Close |
| | 100-150 amp. boiler fuse (2) for each steam gen. "Blown" | Test and replace |
| | 15 amp. control fuse (2 on boiler panel) "Blown" | Test and replace |
| Motor does not run (control switch-102 on "FILL," bell rings) | Stack switch tripped | Reset |
| | Motor overload tripped | Reset |
| | Coil blowdown valve-2 "OPEN" | Close |
| Motor runs, no strong flow of water from water pump test valve | Water tank empty | Fill |
| | Valve-21 on suction line closed (on line to treatment tank) | Open |
| | Drain valve-20 on suction line or treatment tank open | Close |
| | Top of treatment tank not tight | Reset and tighten |
| | Treatment tank strainer clogged | Clean |
| | Water in storage tank too hot | Make sure steam heat valve to water tank is closed |

## VAPOR HEATING OK-SERIES STEAM GENERATOR TROUBLE SHOOTING CHART (CONT'D)

| Symptoms | Cause of Trouble | Remedy |
|---|---|---|
| Motor runs, no spark at electrodes | Wires from electrodes to transformer broken or grounded | Repair |
| | Terminals loose on transformer | Tighten |
| | Gap between electrodes too wide | Reduce gap (should be 3/16") |
| | 15 amp. ignition fuse (2 on boiler panel) "Blown." | Test and replace |
| Motor runs, fire does not light when switch is moved to "Run" | Atomizing air valve-1 closed | Open |
| | Motor not allowed to stop after filling, before turning boiler control switch-102 to "Run" | Turn to "Fill" briefly, then to "Off." After motor has stopped and servo control is all the way down, turn to "Run." |
| | Electrodes not properly adjusted | Adjust. Report to maintenance. |
| | Nozzle not properly adjusted | Adjust. Report to maintenance. |
| Generator shuts off, bell rings | Stack switch tripped | Reset stack switch, refill coils, start steam generator, and set water by-pass regulator at next lower pressure. Report to maintenance. |

## VAPOR HEATING OK-SERIES STEAM GENERATOR TROUBLE SHOOTING CHART (CONT'D)

| Symptoms | Cause of Trouble | Remedy |
|---|---|---|
| Generator shuts off, bell rings | Motor overload relay trips, shutting down generator | Reset overload relay, refill coils and start steam generator. Report to maintenance. |
| Generator runs, dome gets hot | Lack of air, dirty coils | Set water by-pass regulator to next lower position. Report to maintenance. |
| Generator runs but no water returns through water flow indicator | Valve-9 in return line from separator closed | Open |
| | Return water strainer clogged | Clean |
| | Steam too dry | Report to maintenance. |
| Generator runs but generator and train-line pressure cannot be controlled by water by-pass regulator | Steam admission valve-13 closed | Open |
| | Water admission valve-3 closed | Open |
| | Defective water by-pass regulator | Close water shutoff valve-19 to water by-pass regulator, use manual by-pass valve-8 to control pressure. Report to maintenance. |

# STEAM GENERATOR OPERATION CHART

## VALVES

Valves designated by odd numbers are fitted with cross type handles, and must be OPEN during normal operation of the steam generator; valves designated by even numbers are fitted with standard round handles, and must be CLOSED during normal operation of the steam generator. This applies only to the OK series steam generators.

The following valves must be CLOSED during normal operation of the steam generator:

2. Coil Blowdown Valve and Switch
4. Fill-Test Valve
6. Layover Connection Shutoff Valve
8. Manual Water By-Pass Valve
10. Steam Admission Valve to Radiation (Open in cold weather)
12. Steam Separator Blowdown Valve
14. Washout Inlet Valve
16. Washout Inlet Valve
18. Water Pump Test Valve
20. Water Suction Drain Valve
22. Water Treatment Tank Drain Valve
56. Return Line Valve (Standby)

The following valves must be OPEN during normal operation of the steam generator:

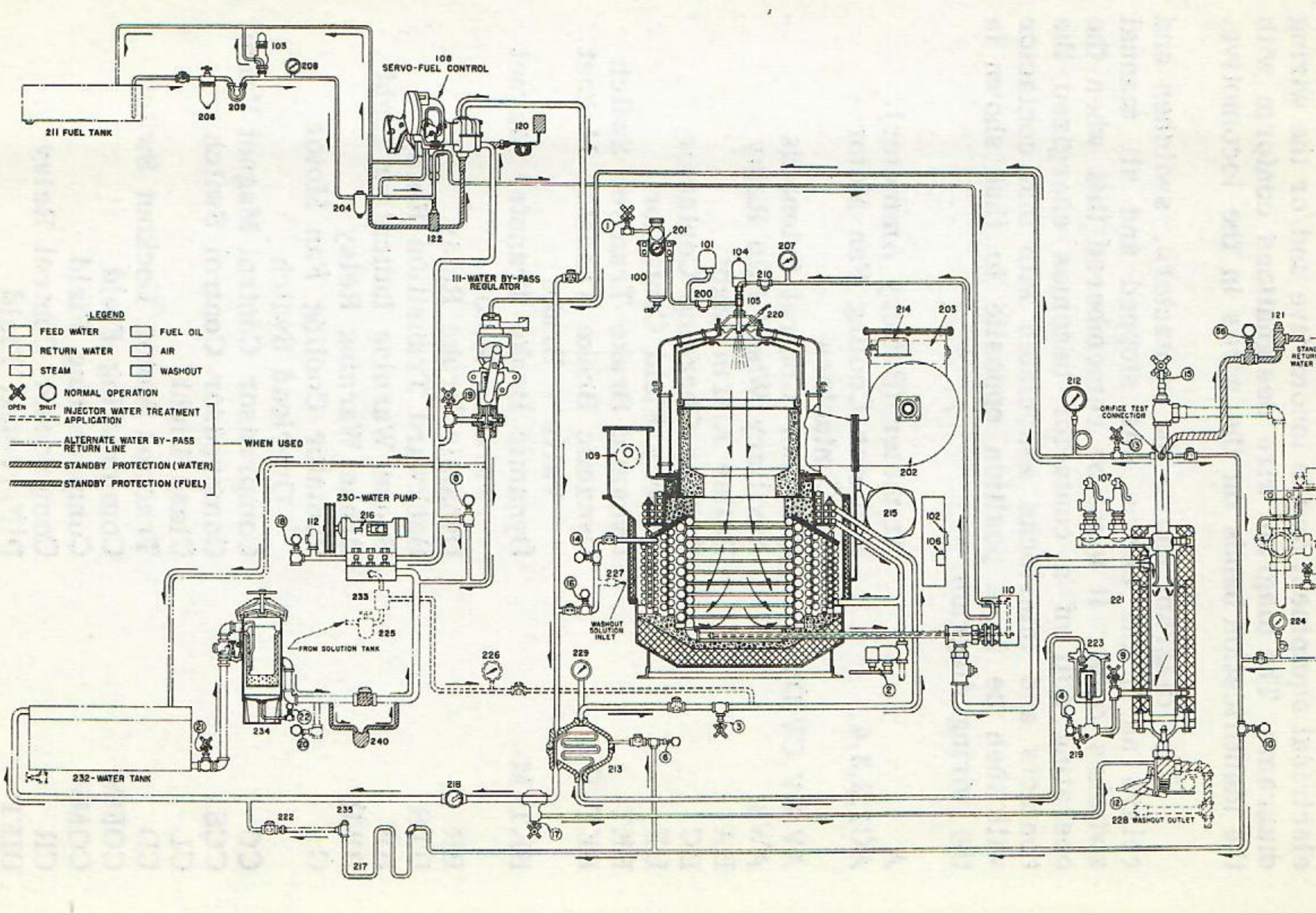
1. Atomizing Air Shutoff Valve
3. Coil Shutoff Valve
7. Remote Control Trainline Shutoff Valve
7a. Reset Lever
9. Return Water Outlet Valve
11. Steam Admission Valve to Trainline Pressure Gauge
13. Steam Admission Valve to Water By-Pass Regulator
15. Stop and Check Valve (Closed during start or shut down procedure)
17. Three-Way Washout Valve
19. Water By-Pass Regulator Shutoff Valve
21. Water Supply Stop Valve

## CONTROLS

100. Atomizing Air Pressure Regulator
101. Atomizing Air Switch
102. Control Switch
103. Fuel Pressure Regulator
104. Fuel Solenoid Valve
105. Fuel Spray Head
106. Overload Reset Button, Motor
107. Safety Valves
108. Servo-Fuel Control and Switch
109. Stack Switch
110. Steam Temperature Limit Control
111. Water By-Pass Regulator and Switch
112. Water Pressure Relief Valve
120. Aquastat (Standby)
121. Relief Valve (Standby)
122. Fuel By-Pass Solenoid Valve (Standby)

## APPURTENANCES

200. Atomizing Air Strainer
201. Atomizing Air Pressure Gauge
202. Blower
203. Damper
204. Fuel Filter (Pressure line)
206. Fuel Filter (Suction line)
207. Fuel Nozzle Pressure Gauge
208. Fuel Pressure Gauge (At fuel pressure regulator)
209. Fuel Pump
210. Fuel Strainer
211. Fuel Tank
212. Generator Steam Pressure Gauge
213. Heat Exchanger
214. Ignition Transformer
215. Motor Converter
216. Oil Filter Cap
217. Radiation
218. Return Water Flow Indicator
219. Return Water Strainer
220. Spark Plugs
221. Steam Separator
222. Orifice Nipple (Radiation)
223. Steam Trap (Return water line)
224. Trainline Steam Pressure Gauge
225. Treatment Injector Filter
226. Treatment Injector Gauge
227. Washout Solution Inlet
228. Washout Solution Outlet
229. Water Pressure Gauge
230. Water Pump
232. Water Tank
233. Water Treatment Injector Pump
234. Water Treatment Tank (Strainer tank only if injector system is used)
235. Strainer Tee
240. Circulating Pump (Standby)


211 FUEL TANK
103
208
209
206
108 SERVO-FUEL CONTROL
120
204
122
111-WATER BY-PASS REGULATOR
201
100
101
104
207
210
200
105
220
214
203
121
STANDBY RETURN TO WATER TANK
212
ORIFICE TEST CONNECTION
107
7A
LEGEND
FEED WATER
RETURN WATER
STEAM
FUEL OIL
AIR
WASHOUT
OPEN
SHUT
NORMAL OPERATION
INJECTOR WATER TREATMENT APPLICATION
ALTERNATE WATER BY-PASS RETURN LINE
STANDBY PROTECTION (WATER)
STANDBY PROTECTION (FUEL)
WHEN USED
230-WATER PUMP
216
112
109
202
215
102
106
110
221
223
224
227
WASHOUT SOLUTION INLET
233
225
FROM SOLUTION TANK
226
229
234
240
232-WATER TANK
213
219
218
222
235
217
228 WASHOUT OUTLET

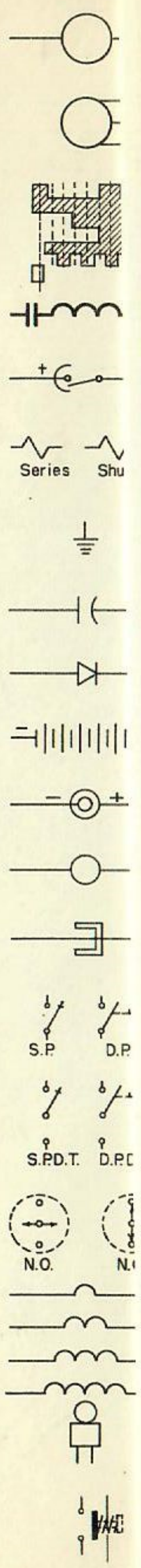
## LEGEND OF ELECTRICAL EQUIPMENT

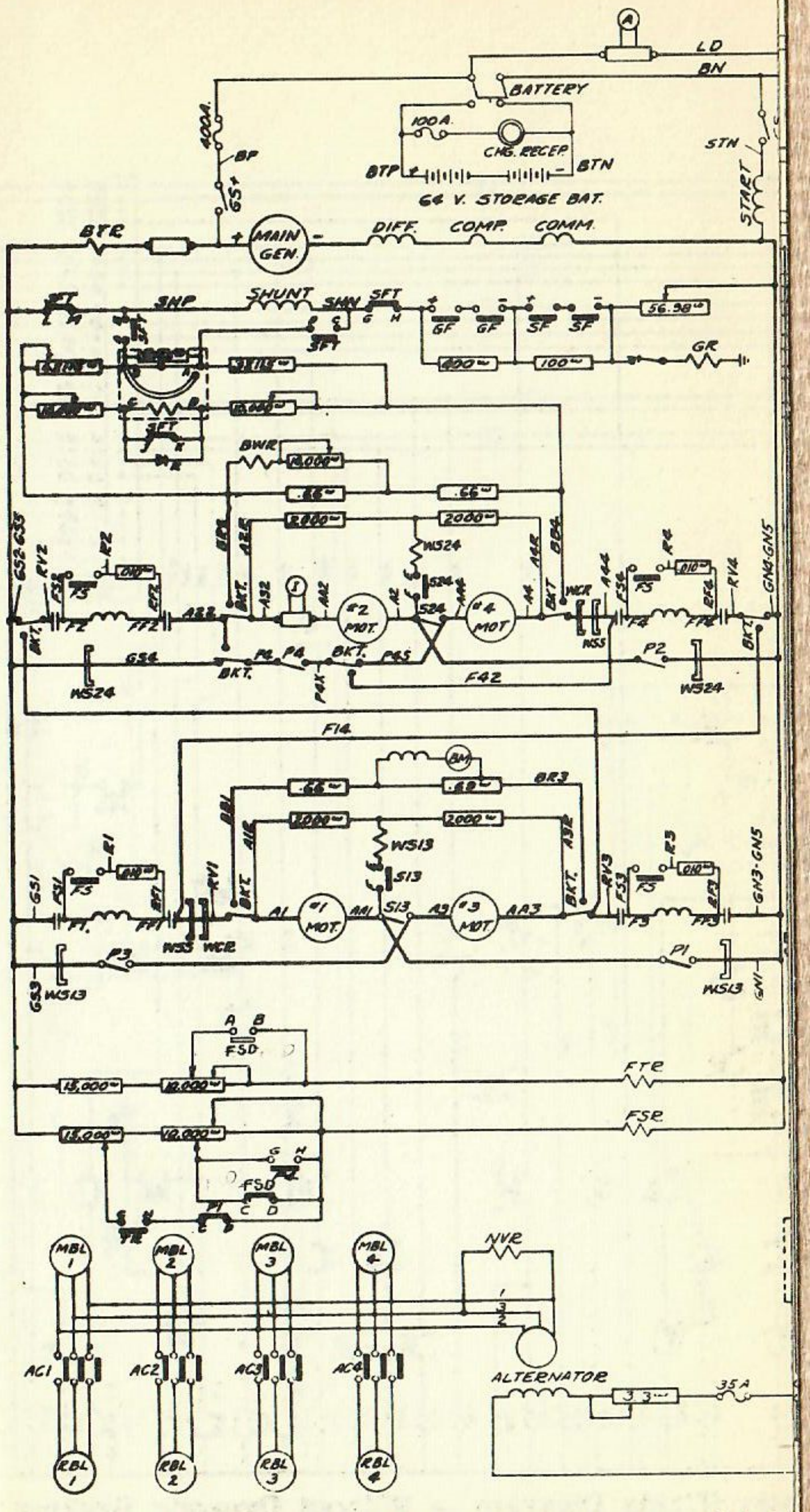
The following list shows abbreviations identifying electrical equipment on the locomotive and/or the wiring diagrams. The diagram wire designations conform with the identification bands on the wires in the locomotive.

The diagram shows the contactors, switches and relays as if the engine was stopped and all manual switches open. It must be remembered that when the operating coil of a contactor becomes energized the contacts and interlocks associated with that contactor will then be in a position opposite to that shown in the wiring diagram.

| | |
|---|---|
| A | Ammeter (Battery Ammeter) |
| AC1,2,3,4 | Radiator Cooling Fan Motor Contactors |
| AV,BV,CV,DV | Governor Control Solenoids |
| AWS | Auxiliary Wheel Slip Relay |
| BA | Boiler Alarm Light |
| BC | Battery Charging Contactor |
| BF | Battery Field Contactor |
| BKT | Dynamic Brake Transfer Switch |
| BKT-B | Dynamic Brake Transfer Magnet Valve - Brake |
| BKT-M | Dynamic Brake Transfer Magnet Valve - Motor |
| BR | Dynamic Brake Relay |
| BTR | Backward Transition Relay |
| BW | Brake Warning Indicating Light |
| BWR | Brake Warning Relay |
| C | Radiator Cooling Fan Motor Overload Switch |
| CC | Compressor Control Magnet Valve |
| CCS | Compressor Control Switch |
| CL | Class Light |
| CD | Traction Motor Lockout Switch |
| COMM | Commutating Field |
| COMP | Compensating Field |
| CR | Compressor Control Relay |
| DIFF | Differential Field |
| ER | Engine Relay (ER Relay) |
| ETS | Engine High Temperature Switch |
| FL | Field Loop Contactor |
| FMV or FSV | Forward Sanding Magnet Valve |
| FPC | Fuel Pump Contactor |
| FS | Traction Motor Field Shunting Contactor |
| FSD | Field Shunting Delay Relay |
| FSR | Field Shunting Relay |
| FTR | Forward Transition Relay |
| GA | Gauge Light or Switch |
| GF | Generator Field Contactor |
| GR | Ground Relay |
| GS$^{\pm}$ or ST$^{\pm}$ | Generator Starting Contactors |
| I | Dynamic Brake and Load Indicating Meter |
| IS | Isolation Switch |
| LOS | Low Oil Pressure Switch |
| LRC | Load Regulator Contactor |
| LRS | Load Regulator Contactor Switch (In Governor) |
| MBL | Traction Motor Blower Motor |
| NV | "Alternator Failure" or "No Power" Signal Light |
| NVR | "No AC Voltage" Relay |
| OLS | Governor Overload Switch |
| ORS | Governor Over-Riding Solenoid |
| OS | Low Oil Signal Light |
| P | Parallel Power Contactor |
| PCR | Pneumatic Control Relay |
| PCS | Pneumatic Control Switch |
| RBL | Radiator Cooling Fan Blower Motor |
| RCR | Reverse Current Relay |
| RMV or RSV | Reverse Sanding Magnet Valve |
| RVR | Reverser Switch |
| RVR-F or FOR | Forward Magnet Valve or Reverser Switch |
| RVR-R or REV | Reverse Magnet Valve or Reverser Switch |
| S | Series Power Contactor |
| SF or SH | Shunt Field Contactor |
| SFT | Shunt Field Transfer Relay |

| | |
|---|---|
| SMV | Shutter Magnet Valve |
| SR | Signal Relay |
| START | Starting Field |
| SWS | Summer-Winter Switch |
| TA-B-C-D | A-B-C and D Temperature Control Switches |
| TCR | Temperature Control Relay |
| TDB | Time Delay Backward |
| TDO | Time Delay Overload |
| TDR | Time Delay Relay |
| TDS | Time Delay Sanding Relay |
| TR | Transition Relay |
| TS | High Temperature (Hot engine) Signal Light |
| WCR | Wheel Creep Relay |
| WS | Wheel Slip Relay |
| WSA | Wheel Slip Auxiliary Relay |
| WSS | Wheel Slip Series Relay |

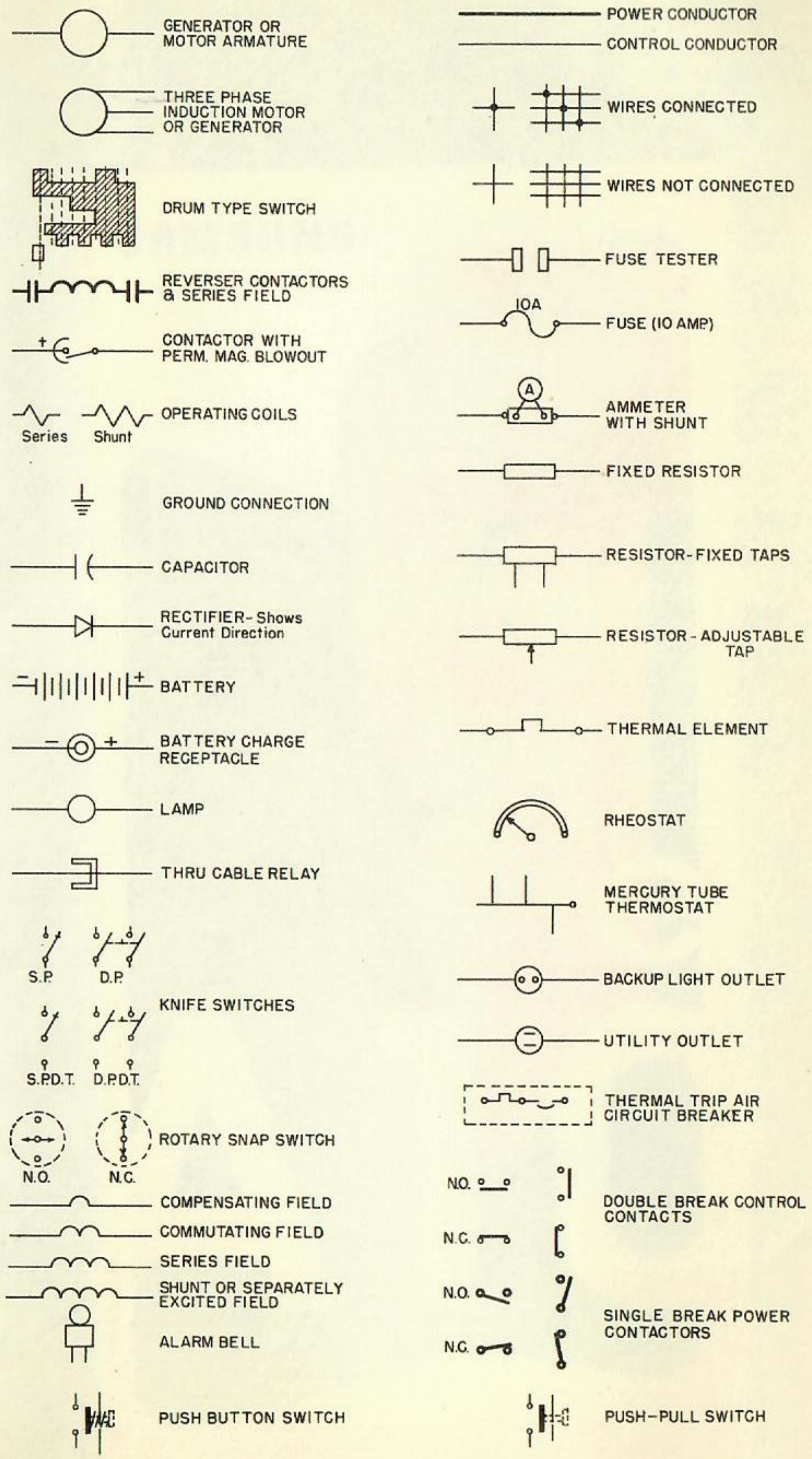

Series
Shu
S.P.
D.P.
S.P.D.T.
D.P.D
N.O.
N.

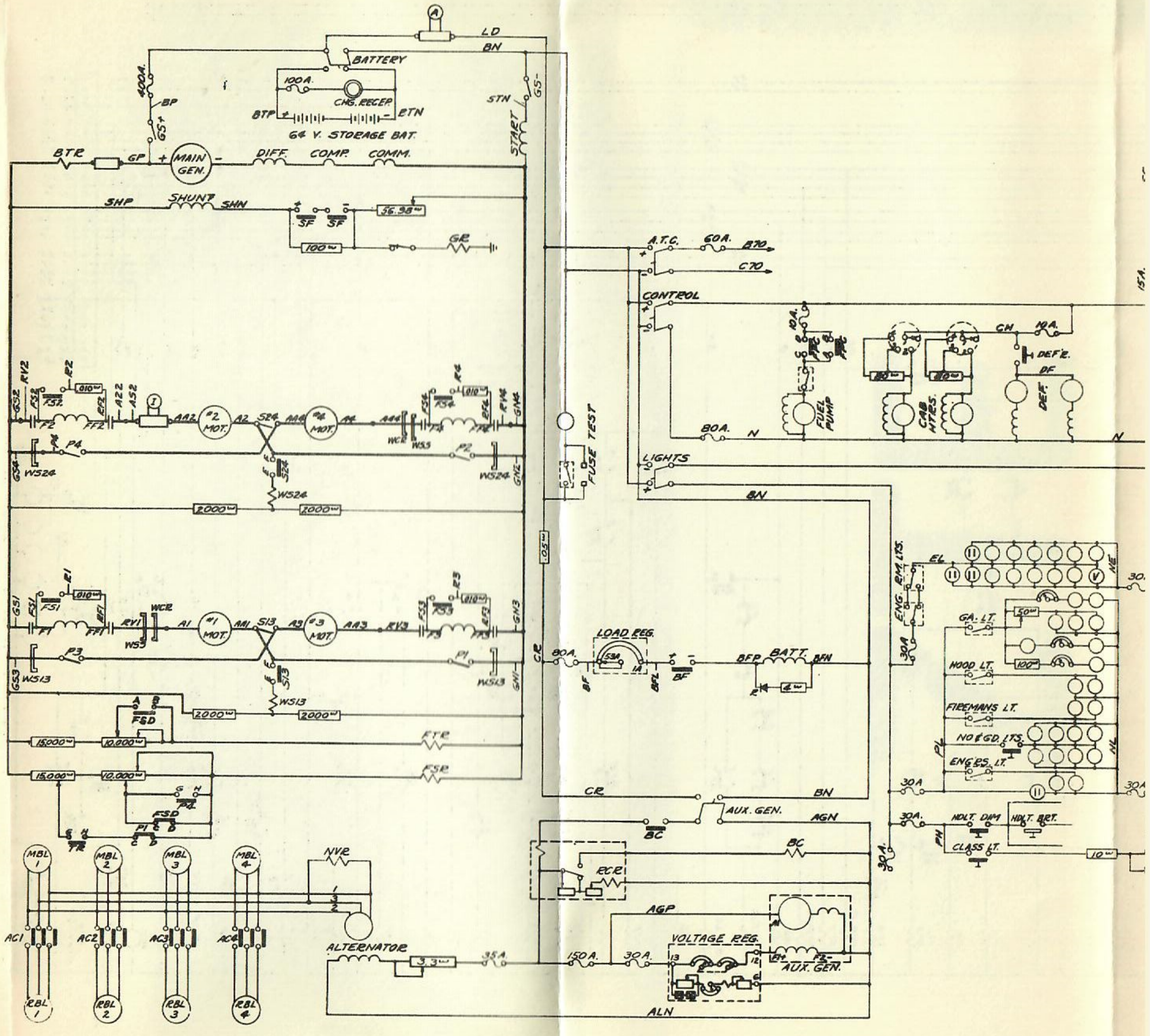

A
LD
BN
BATTERY
400A.
100A.
CHG. RECEP.
BP
BTP
BTN
64 V. STORAGE BAT.
GS+
STN
START
BTR
MAIN GEN.
DIFF.
COMP.
COMM.
SFT
SHP
SHUNT
SHN
GF
SF
56.98
400
100
GR
BWR
10,000
.66
2000
WS24
S24
#2 MOT.
#4 MOT.
BKT.
GS4
F42
P2
P4
P4X
P45
F14
BM
BR3
WS13
S13
#1 MOT.
#3 MOT.
A1
AA1
A3
AA3
RV1
RV2
RV3
RV4
R1
R2
R3
R4
F5
.010
WS5
WCR
P1
P3
GS1
GS2
GS3
GH3-GN5
GN4-GN5
GN1
A
B
FSD
C
D
G
H
15,000
10,000
FTR
FSR
TR
MBL 1
MBL 2
MBL 3
MBL 4
AC1
AC2
AC3
AC4
RBL 1
RBL 2
RBL 3
RBL 4
NVR
ALTERNATOR
3.3
35A

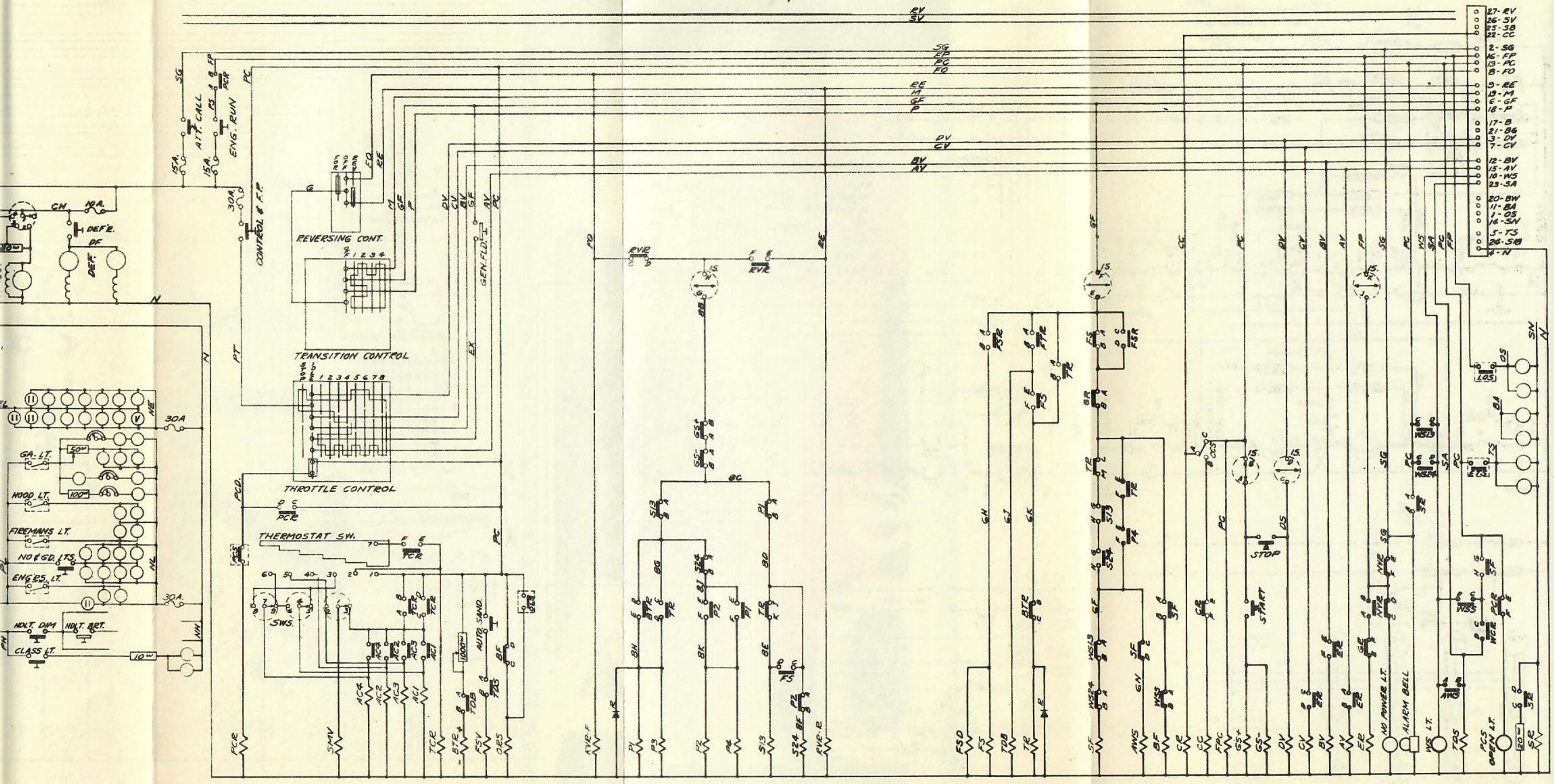
Typical F9 Schematic Wiring Diagram — With D

Plate 7238 — January 1, 1954

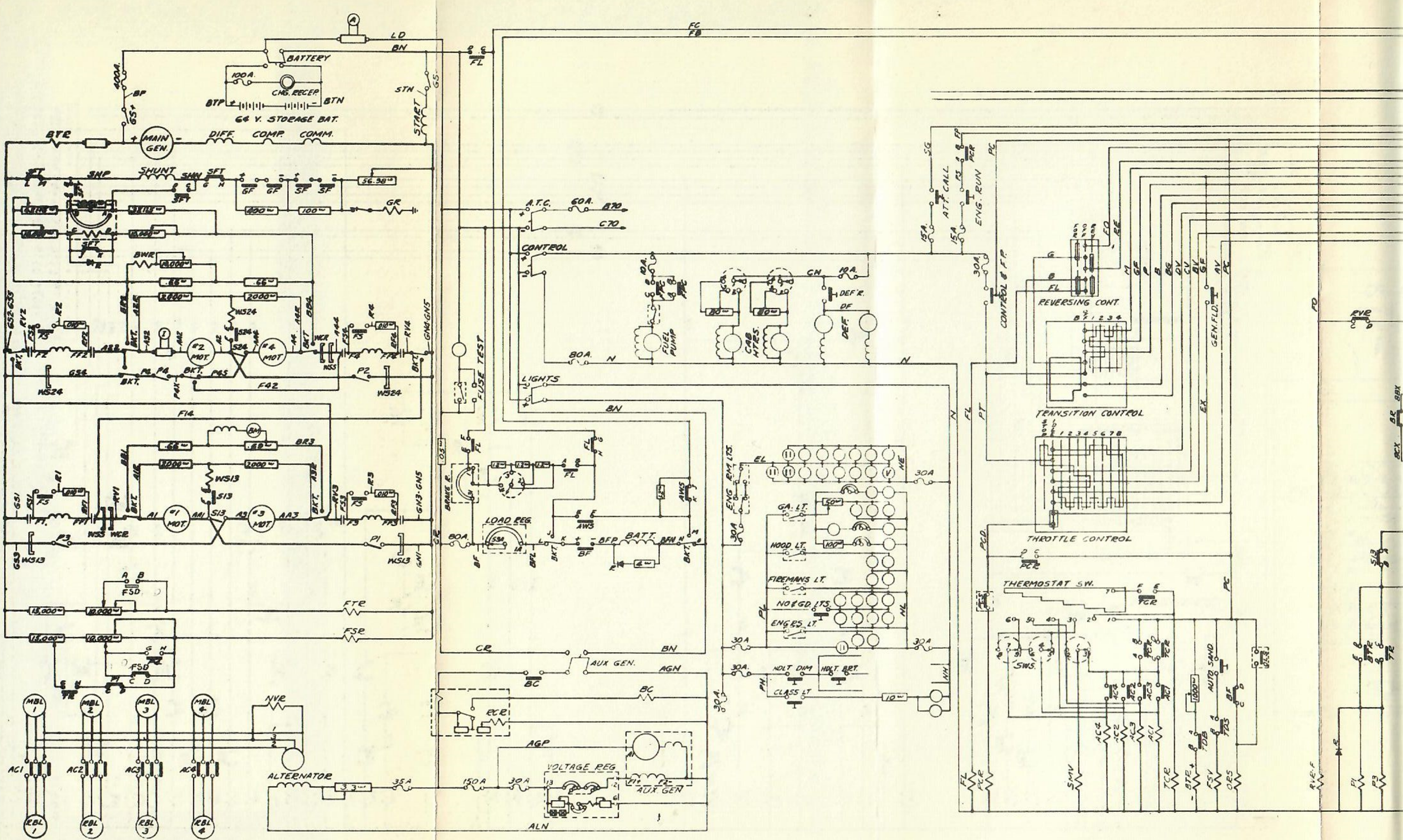
## Electrical Symbols


GENERATOR OR MOTOR ARMATURE
THREE PHASE INDUCTION MOTOR OR GENERATOR
DRUM TYPE SWITCH
REVERSER CONTACTORS & SERIES FIELD
CONTACTOR WITH PERM. MAG. BLOWOUT
Series
Shunt
OPERATING COILS
GROUND CONNECTION
CAPACITOR
RECTIFIER - Shows Current Direction
BATTERY
BATTERY CHARGE RECEPTACLE
LAMP
THRU CABLE RELAY
S.P.
D.P.
KNIFE SWITCHES
S.P.D.T.
D.P.D.T.
N.O.
N.C.
ROTARY SNAP SWITCH
COMPENSATING FIELD
COMMUTATING FIELD
SERIES FIELD
SHUNT OR SEPARATELY EXCITED FIELD
ALARM BELL
PUSH BUTTON SWITCH
POWER CONDUCTOR
CONTROL CONDUCTOR
WIRES CONNECTED
WIRES NOT CONNECTED
FUSE TESTER
IOA
FUSE (IO AMP)
A
AMMETER WITH SHUNT
FIXED RESISTOR
RESISTOR - FIXED TAPS
RESISTOR - ADJUSTABLE TAP
THERMAL ELEMENT
RHEOSTAT
MERCURY TUBE THERMOSTAT
BACKUP LIGHT OUTLET
UTILITY OUTLET
THERMAL TRIP AIR CIRCUIT BREAKER
N.O.
N.C.
DOUBLE BREAK CONTROL CONTACTS
N.O.
N.C.
SINGLE BREAK POWER CONTACTORS
PUSH-PULL SWITCH

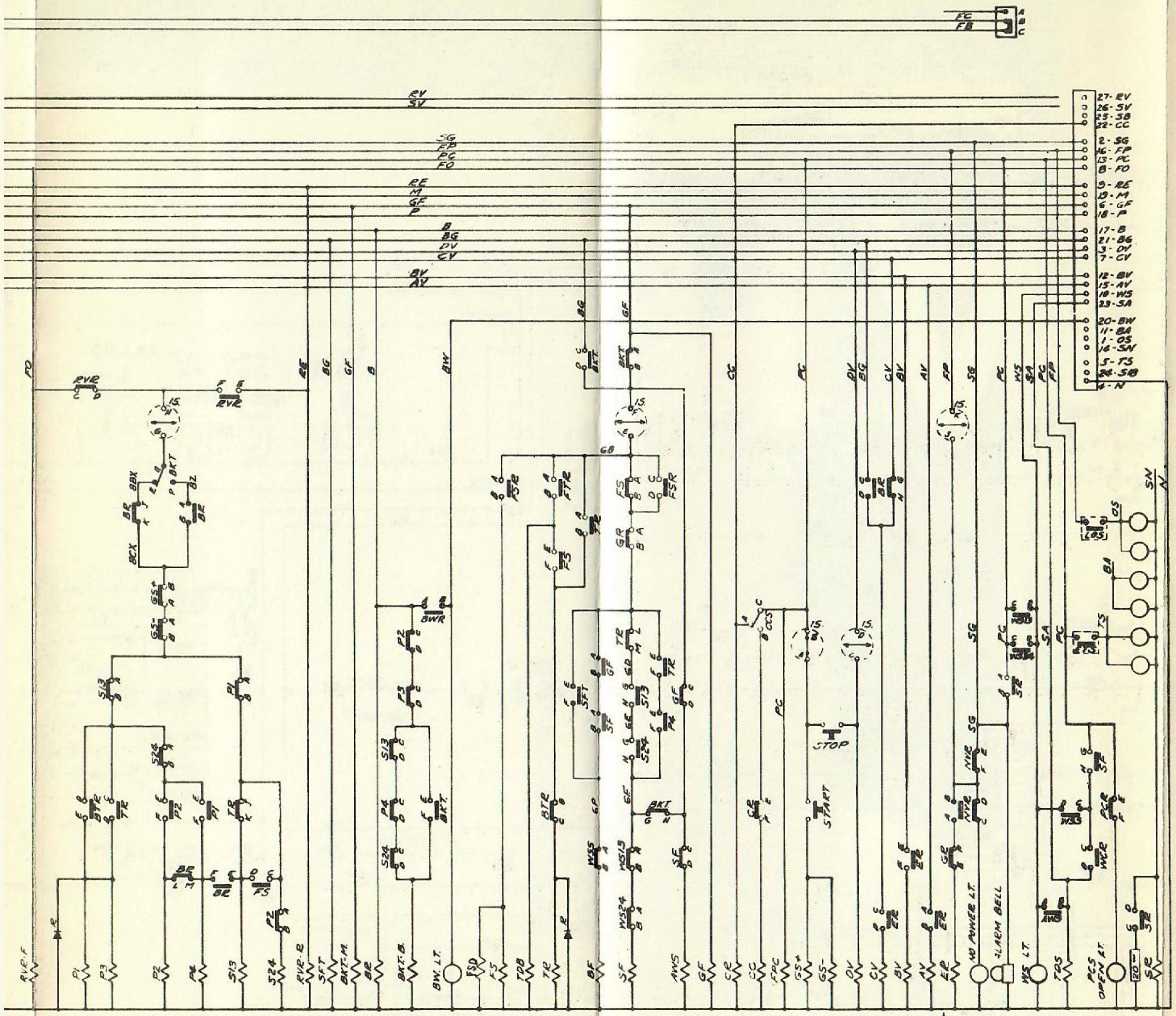

A
LD
BN
BATTERY
400A.
BP
GS+
100A.
CHG. RECEP.
BTP
BTN
64 V. STORAGE BAT.
STN
GS-
START
BTR
GP
MAIN GEN.
DIFF.
COMP.
COMM.
SHP
SHUNT
SHN
SF
SF
56.98
100
GR
A.T.C.
60A.
B70
C70
CONTROL
10A.
FUEL PUMP
CAB HTRS.
GH
10A.
DEF'R.
DF
DEF.
80A.
N
N
LIGHTS
BN
FUSE TEST
RV2
R2
GS2
FS2
A22
AS2
I
AA2
#2 MOT.
A2
S24
AA4
#4 MOT.
A4
AA4
FS4
R4
RV4
GN4
F2
FF2
EF2
WCR
WS5
F4
FF4
P4
P2
GS4
WS24
WS24
GN2
WS24
2000
2000
.05
R1
GS1
FS1
RV1
WCR
A1
#1 MOT.
AA1
S13
A3
#3 MOT.
AA3
RV3
FS3
R3
GN3
F1
FF1
EF1
WS5
F3
FF3
P3
P1
GS3
WS13
WS13
GN1
WS13
CR
80A.
LOAD REG.
BF
BFL
BF
BFP
BATT.
BFN
R
ENG. RM. LTS.
EL
NE
30A
30A.
GA. LT.
50
HOOD LT.
100
FIREMANS LT.
NO & GD. LTS.
ENG. PS. LT.
PL
HL
V
A
B
FSD
2000
2000
15000
10,000
FTR
15,000
10,000
FSR
G
H
FSD
P1
C
D
G
H
FR
CR
BN
AUX. GEN.
AGN
BC
BC
RCR
30A.
30A.
HDLT. DIM
HDLT. BRT.
CLASS LT.
PH
30A.
10
MBL 1
MBL 2
MBL 3
MBL 4
NVR
AC1
AC2
AC3
AC4
ALTERNATOR
3.3
35A
150A.
30A.
AGP
VOLTAGE REG.
AUX. GEN.
ALN
RBL 1
RBL 2
RBL 3
RBL 4


RV
SV
SG
FP
PC
FO
RE
M
GF
P
DV
CV
BV
AV
27-RV
26-SV
25-SB
22-CC
2-SG
16-FP
13-PC
8-FO
9-RE
19-M
6-GF
18-P
17-B
21-BG
3-DV
7-CV
12-BV
15-AV
10-WS
23-SA
20-BW
11-BA
1-OS
14-SN
5-TS
24-SB
4-N
ATT. CALL
ENG. RUN
CONTROL & F.P.
15A.
30A.
10A.
GH
DEF'R.
DF
DEF.
N
PT
REVERSING CONT.
TRANSITION CONTROL
THROTTLE CONTROL
GEN. FLD.
EX
G
PCR
PCD.
THERMOSTAT SW.
TCR
SWS.
AUTO SAND.
TDB
TDS
BF
AC4
AC2
AC3
AC1
SMV
TCR
BTR
FSV
ORS
GA. LT.
HOOD LT.
FIREMANS LT.
NO & GD. LTS.
ENG. RS. LT.
HDLT. DIM
HDLT. BRT.
CLASS LT.
NE
NL
HH
PL
30A.
50w
100w
10w
RVR
RVR-F
RVR-R
RE
BB
GS
GS+
BC
S13
S24
P1
P2
P3
P4
BG
BD
BH
BK
BE
TR
FS
FSD
FSR
FTR
TDB
GH
GJ
GK
SR
SF
WS13
WS24
AWS
GN
CR
CC
FPC
STOP
START
OS
OV
GV
BV
AV
ER
GR
NVR
NO POWER LT.
ALARM BELL
WS LT.
TDS
PCS
PCS OPEN LT.
LOS
WSS
WCR
SN
BA
TS
TFS
20w

**Typical F9 Schematic Wiring Diagram – Without Dynamic Braking**
**Plate 7237 – January 1, 1954**


BATTERY
100A.
CHG. RECEP.
BTP
BTN
64 V. STORAGE BAT.
400A.
BP
GS+
LD
BN
STN
START
GS-
BTR
MAIN GEN.
DIFF.
COMP.
COMM.
SFT
SHP
SHUNT
SHN
GF
SF
56.38
400
100
GR
BWR
10,000
.66
2000
WS24
S24
#2 MOT.
#4 MOT.
#1 MOT.
#3 MOT.
G52-G53
RV2
F2
FF2
GS4
P4
P2
BKT.
F42
F14
BR3
WS13
S13
A1
AA1
A3
AA3
G51
F1
F3
WS3
WCR
P3
P1
G53
GN1
RV1
R1
R3
GN3-GN5
GN4-GN5
FSD
15,000
10,000
FTR
FSR
TR
MBL 1
MBL 2
MBL 3
MBL 4
AC1
AC2
AC3
AC4
RBL 1
RBL 2
RBL 3
RBL 4
NVR
ALTERNATOR
35A
3.3
FC
FB
FL
A.T.C.
60A.
B70
C70
CONTROL
80A.
N
FUSE TEST
LIGHTS
BN
FUEL PUMP
CAB HTRS.
CH
10A.
DEF'R.
DF
DEF.
BRAKE R.
LOAD REG.
80A.
BF
BFL
AWS
BATT.
BFP
BFN
ENG. RM. LTS.
EL
HE
30A
GA. LT.
HOOD LT.
FIREMANS LT.
NO. & GD. LTS.
ENG. BS. LT.
NL
HDLT. DIM
HDLT. BRT.
CLASS LT.
NH
CR
AUX. GEN.
AGN
BC
RCR
AGP
VOLTAGE REG.
150 A
30 A
AUX. GEN.
ALN
SG
ATT. CALL
15A.
ENG. RUN
PCR
PC
30A
CONTROL & F.P.
REVERSING CONT.
TRANSITION CONTROL
THROTTLE CONTROL
GEN. FLD.
EX
PT
PCD
THERMOSTAT SW.
SWS.
AUTO SAND
OLS
FDB
FSV
ORS
SMV
TCR
AC4
AC2
AC3
AC1
PD
RVR
BR
BBX
S13
RVR-F
P1
P3

Typical F9 Schematic Wiring Diagram — With Dynamic Braking
Plate 7238 — January 1, 1954


FC
FB
RV
SV
SG
FP
PC
FO
RE
M
GF
P
B
BG
DV
CV
BV
AV
27-RV
26-SV
25-SB
22-CC
2-SG
16-FP
13-PC
8-FO
9-RE
19-M
6-GF
18-P
17-B
21-BG
3-DV
7-CV
12-BV
15-AV
10-WS
23-SA
20-BW
11-BA
1-OS
14-SN
5-TS
24-SIB
4-N
RVR
BKT
BR
BZ
GS+
GS-
S13
S24
P1
P2
P3
P4
TR
BTR
FS
BWR
GB
FSR
FTR
FSR
GR
SFT
SF
GD
GP
AWS
WSS
WS13
WS24
CCS
STOP
START
NVR
LOS
OS
BA
TS
SN
N
WSR
PCR
WCR
RVR-F
P1
P3
P2
P4
S13
S24
RVR-R
SVT
BKT-M
BE
BKT-B
BW. LT.
FSD
FS
TDB
TR
BF
SF
AWS
GF
CR
CC
FPC
GS+
GS-
DV
CV
BV
AV
ER
NO POWER LT.
ALARM BELL
WS LT.
TDS
PCS OPEN LT.
20Ω
SR